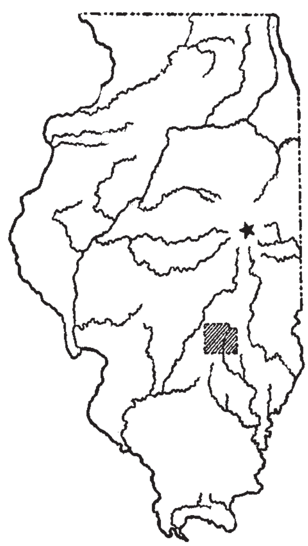
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 48

EFFINGHAM COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH



URBANA, ILLINOIS, FEBRUARY, 1931

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

[1] Engaged in Soils Extension as well as in Soil Experiment Fields

INTRODUCTORY NOTE

IT IS A MATTER of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil management, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation.

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APPENDIX

EFFINGHAM COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

GEOGRAPHICAL FEATURES OF EFFINGHAM COUNTY

EFFINGHAM COUNTY is located in the south-central part of Illinois. It lies about twenty miles south of the Shelbyville moraine, which marks the dividing line between the dark-colored, corn-belt soil region to the north and the light-colored, mature soil region to the south. The county is practically rectangular in shape, being 24 miles east and west by about 21 miles north and south. It comprizes an area of about 469 square miles.

Climate

The climate of Effingham county is characterized by a wide range in temperature between the extremes of winter and summer and by an abundant rainfall. According to the records of the U. S. Weather Bureau stations located at Montrose and Effingham, the highest temperature for the period 1912 to 1929 was 110°, which occurred in 1918; the lowest, 24° below zero, in 1915. The average date of the last killing frost in spring is April 22; the earliest in autumn is October 16. The average length of growing season is 177 days, which is ample time to mature the crops commonly grown in the region. Occasionally early frosts produce soft corn in years when backward spring conditions cause delay in planting. Winter wheat also often suffers injury, particularly on flat land, owing to freezing and thawing and to water standing over it. Periods of heat in early summer frequently cut the yield of spring grain. A prolonged period of hot weather, usually accompanied by drouth, sometimes reduces the yield of corn.

The average annual rainfall for the eighteen-year period, 1912 to 1929, was 41.06 inches, about 23 inches of which came during the growing season. The wettest year on record, 1927, had a total rainfall of more than 65 inches; the driest year, 1914, had about 25 inches. The wettest and driest months occurred, respectively, in May, 1915, which had a record of nearly 11½ inches of rain, and July, 1921, which had only ⅓ of an inch.

Fig. 1 shows the average monthly distribution of rainfall. An average rainfall of 23 inches during the growing season would indicate that Effingham county soils receive enough water to maintain a proper moisture supply for the growing crops and that drouths would not occur. It should be borne in mind, however, that the total amount of precipitation is only one of the factors that control drouth; other important factors are humidity, rate of evaporation, rate at which rain falls, lapse of time between rains, and drainage conditions.

The clay pan underlying the soils developed on flats plays a dual role in producing unfavorable moisture conditions. It impedes movement of water

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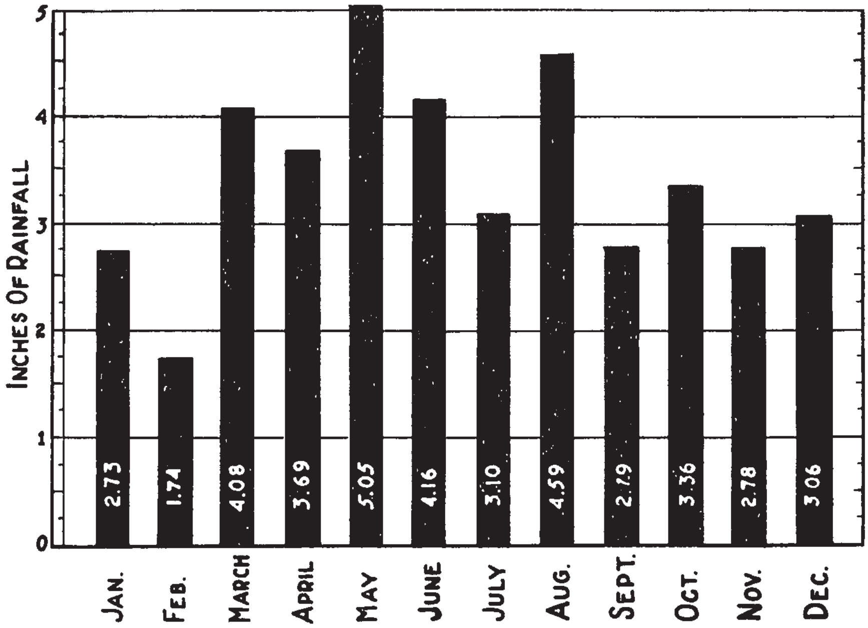

FIG. 1.—AVERAGE MONTHLY RAINFALL IN EFFINGHAM COUNTY

This chart is intended to give only a general idea of the seasonal distribution of rainfall. To depict accurately moisture conditions it would be necessary to show for each year the amount of water falling in each rain and the time elapsing between rains, as well as other conditions of soil and atmosphere.

downward in the rainy season, thus producing a water-logged condition. On the other hand, it cuts off movement of water upward at the time of rapid evaporation from the surface, thus causing the moisture supply of the surface soil soon to become exhausted. Thus the yields of such crops as corn, soybeans, cowpeas, and hay are often reduced by drouthy conditions in the soil.

Prolonged spring rains and hard, dashing thunder showers in summer are likely to be more detrimental than beneficial, on account of the destructive erosion caused by the run-off water. Several rains of such destructive nature occur in this region every year. Run-off during hard rains makes the control of erosion on cultivated areas, particularly on rolling land, a serious problem. In the bottom lands loss of crops by flooding often occurs as a result of heavy rains.

Physiography and Drainage

The general elevation of Effingham county is about 600 feet above sea level. This territory was once a monotonously flat plain with a very gentle southward slope, generally less than three feet to the mile. Drainage and erosion have since created some rolling and rough land along the streams. The gullied land is closely confined to the streams and lies in sharp contrast to the flat upland into which it abruptly merges. A few low knolls and ridges rising 20 to 40 feet above the level of the surrounding territory are found in the northwestern and central-eastern parts of the county. The southeastern part is extremely level.

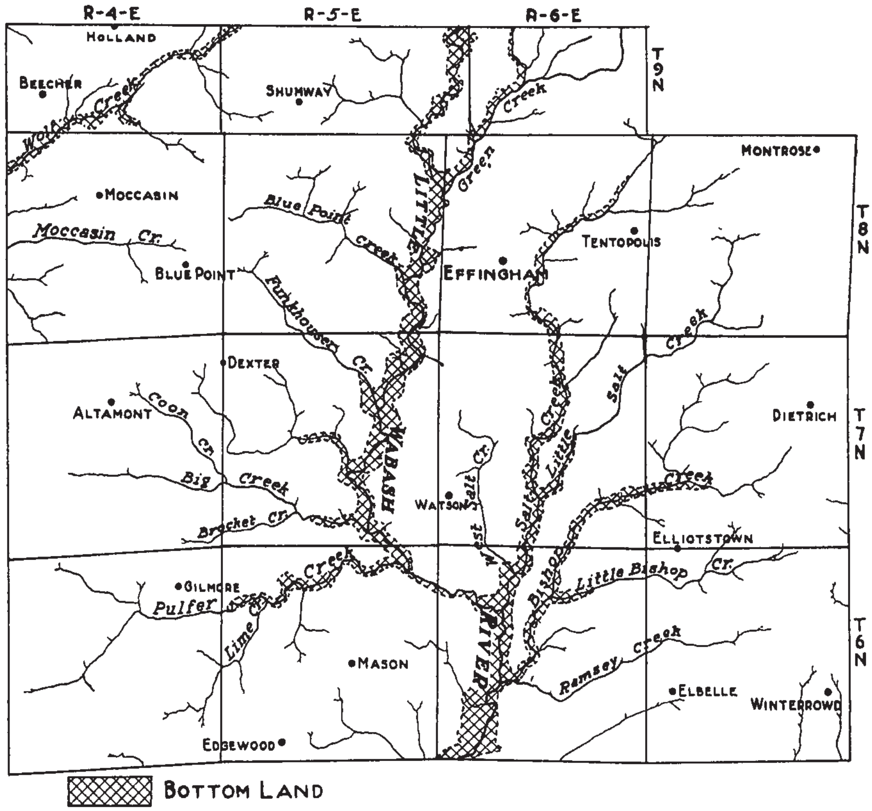

FIG. 2.—DRAINAGE MAP OF EFFINGHAM COUNTY SHOWING STREAM COURSES

Natural drainage in Effingham county is not very well developed. Stream courses ramify the entire area of the county but on account of the nearly level upland topography they drain only the land near their channels. The principal drainage outlet is Little Wabash river which flows south thru the middle of the county. An area of about 60 square miles in the northwestern part of the county is drained by branches of Kaskaskia river (see Fig. 2).

The soils of Effingham county, except those adjacent to stream courses, are of such nature as to impede free movement of water thru them. This condition combined with the level topography makes the land poorly drained. A thoro system of surface-ditching is necessary for drainage on the flat land and special attention must be given to provision for outlets. Tile will not work because of the tight subsoil. Open surface ditches properly made will remove the excess water during wet seasons, but no means of maintaining moisture in the surface soil during dry times is known. The rolling land along streams drains well, but where the land is under cultivation erosion becomes a problem. The bottom-land soils are well drained but they are frequently flooded in times of overflow.

Social Development

The first white man to settle within the region that is now Effingham county took up his residence in 1814. Effingham county was organized as such in 1831.

Many settlers from Ohio and Indiana came in the fifties and sixties, and population increased rapidly until about 1880. This growth in population is represented in Fig. 3. The 1930 Census Report gives 19,013 as the number of inhabitants. About two-thirds of the population is recorded as rural. A shift from rural communities to urban centers has taken place in later years, with the result that a number of former prosperous rural settlements have entirely disintegrated.

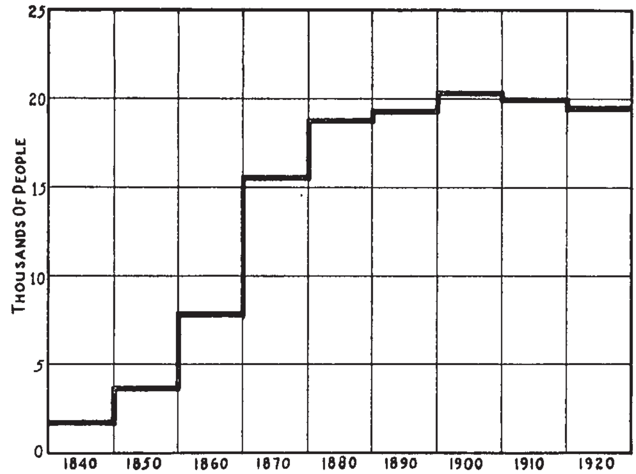

FIG. 3.—GROWTH IN POPULATION OF EFFINGHAM COUNTY
Population reached its maximum in the first decade of the present century, since which time it has declined.

Transportation is well provided. Two trunk-line railroads intersect at Effingham and four branch lines operate in the county. The auto truck has developed into an important means of local, as well as long distance, transportation.

Educational facilities and social life are well developed in rural communities. General agricultural conditions bespeak moderate prosperity thruout the rural sections.

Agricultural Production

Early agriculture in Effingham county was confined mainly to small fields which had been cleared along the edge of the timber. Vegetables, cereals, and hay were raised in quantities nearly sufficient to meet the needs of home consumption. A few animals were fattened and driven overland to the St. Louis market. Most of the land remained in grass, serving as pasture for livestock. Until 1850 there were not more than 50,000 acres of land in farms. After that time the cultivated land increased rapidly along with the increase in population until 1880, but the tendency since 1890 has been toward a reduction in acreage. The average size of farm in 1920 was about 123 acres. The proportion of tenancy in the county at that time is given as about 28 percent.

An idea of the principal crops grown in Effingham county is obtained from the following data taken from Circular 385, Illinois Crop and Livestock Statistics, issued by the Illinois Department of Agriculture in cooperation with the

U. S. Department of Agriculture. The figures give the acreage, production, and yield per acre of most of the important field crops for the year 1928:

Crop	*Acreage*	*Production*	*Yield per acre*
Corn	59,900	1,437,600 bu.	24.0 bu.
Wheat (winter)	3,400	34,000 bu.	10.0 bu.
Wheat (spring)	200	1,600 bu.	8.0 bu.
Barley	260	5,460 bu.	21.0 bu.
Rye	580	5,220 bu.	9.0 bu.
Oats	40,500	1,255,500 bu.	31.0 bu.
Tame hay	48,000	52,800 tons	1.1 tons
Wild hay	140	154 tons	1.1 tons
White potatoes	730	75,920 bu.	104.0 bu.
Sweet potatoes	75	8,550 bu.	114.0 bu.
Broom corn	380	121,600 lbs.	320.0 lbs.
Soybeans (alone)	12,000	......	....
Soybeans (as companion crop)	5,000	......	....
Cowpeas	1,000	......	....
Alfalfa	250	......	....
Sweet clover	5,000	......	....

It should be borne in mind that these figures are for a single year only and that yields fluctuate from year to year, depending largely on the weather. The U. S. Department of Agriculture gives the average yield per acre of the four most important crops in Effingham county from 1911 to 1929 as: corn, 22.4 bushels; wheat, 12.2; oats, 18.3; and hay, .98 ton. Thus it appears that the season of 1928 was unfavorable for wheat but very favorable for the oats crop.

The predominance of acreage given over to the growing of grains and other nonlegume crops, as shown in Fig. 4, indicates that more diversification of crops might well be practiced. The legume acreage, according to the Census figures, is less than one-thirtieth of the total acreage. At least one-fourth of the cropped area should be in legumes every year. The acreage of sweet and red clover and alfalfa in the county is increasing, but too slowly. Cowpeas and soybeans, altho not so efficient for soil improvement as the clovers, are good legume crops and the acreage of these crops might well be increased.

Fruits and vegetables are not of great commercial importance in Effingham county altho a few orchards have been planted in the northern part of the county.

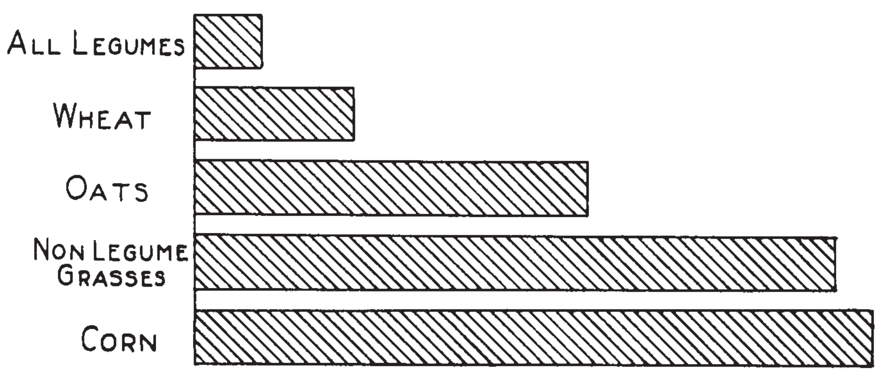

FIG. 4.—RELATIVE ACREAGE OF PRINCIPAL FIELD CROPS IN EFFINGHAM COUNTY

The diagram brings out the small proportion of land devoted to legumes. A well-balanced system for soil improvement demands a much larger acreage of legume crops. (Data from U. S. Census of Agriculture, 1925)

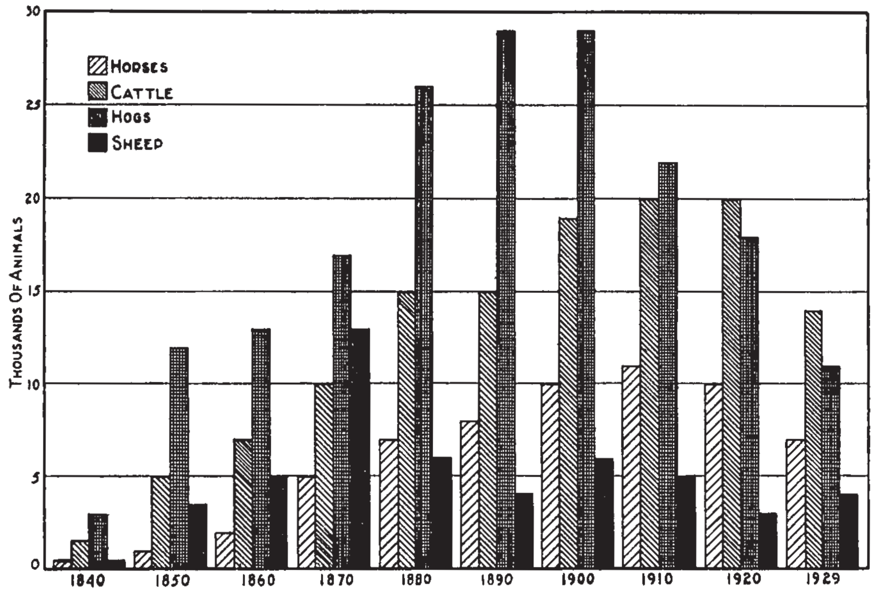

FIG. 5.—NUMBER OF HORSES, CATTLE, HOGS, AND SHEEP IN EFFINGHAM COUNTY

The diagram shows the relative numbers of the principal classes of livestock at periodic intervals since 1840. (Figures from the U. S. Census, except for 1929, for which the estimates of the U. S. Bureau of Agricultural Economics and the Illinois State Department of Agriculture are used.)

Apples and peaches are the chief fruits. There is some small-fruit acreage, particularly strawberries, in the southern part of the county. These enterprises when carefully managed have proved profitable. Practically all the vegetables raised are consumed at home or sold at roadside markets.

Livestock production has been an important part of the agriculture of Effingham county. Fig. 5 shows the number of horses, cattle, hogs, and sheep in the

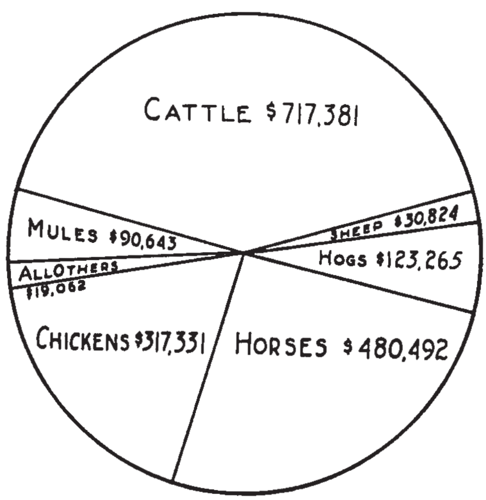

FIG. 6.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN EFFINGHAM COUNTY
(Data from U. S. Census of Agriculture, 1925)

county at periodic intervals since 1840. Animal production reached its maximum in the decade from about 1890 to 1900, and since then the number has declined, particularly the number of hogs. The decline shown in the number of cattle in the last decade has reference to beef cattle.

The total value of animals on farms, as reported in the 1925 Census, was $1,779,174. The relative value of the different kinds of livestock is shown in Fig. 6. Dairying and poultry raising have been the most profitable livestock enterprises during the past few years.

FORMATION OF EFFINGHAM COUNTY SOILS

Sources of Soil Materials

The bed rock underlying the unconsolidated surface mantle of which the present soil is a part was formed during a remote period in geological time. This rock is exposed in only a few places in Effingham county and is of little significance so far as the soil is concerned.

The surface of the bed rock is rough and broken, and were it not for the deposit of the overlying material the surface would be largely hilly and unsuited to farming. A change in regional climate closed the cycle of erosion which made the surface hilly. Another geological period followed during which was deposited the material that later formed the mineral portion of the present soil.

During this more recent geological period, known as the Glacial epoch, snow and ice accumulated in regions to the north in such enormous amounts that the mass pushed outward from these centers. The ice advanced chiefly southward, aided by further accumulations of snow at its margin, until it reached a place where the climate was warm enough to melt the ice as rapidly as it advanced. In moving across the country the ice gathered up all sorts and sizes of materials, including clay, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried hundreds of miles, and rubbing against surface rocks and against each other they were largely ground into powder. The major portion of the material carried, however, was derived from the old eroded bed-rock surface and was usually deposited within fifty miles of its source. When the ice sheet, or glacier, reached the limit of its advance the rock material carried by it accumulated along the ice front in a broad undulating ridge, or moraine. With rapid melting the glacier receded, depositing the material irregularly over the surfaces previously covered by the ice. Each advance and retreat of the glacier helped to level off the hills and fill in the valleys. The mixture of materials deposited by the glaciers is known as glacial drift, or simply drift, a term that will be frequently used in describing soil types.

There were several of these great glacial advances separated by long intervals of warmer climate when the country became clothed with vegetation. At least two of these glaciers reached the region which now includes Effingham county. Remnants of the deposit left there by one of the earlier advances have been found in several places in the county. The Illinoian glaciation, coming later, completely covered the county and buried or destroyed any previous glacial deposits. The deposits left by the Illinoian glacier were a heterogeneous gravelly mass of drift

varying in thickness from twenty to more than a hundred feet and having a nearly level surface.

The water flowing away from the melting glaciers carried in suspension immense quantities of finely ground rock particles which were deposited along the stream courses. Later, as the stream courses became dry, this fine material was picked up by the wind and carried to the upland where it was redeposited as a vast dust blanket over the country. This fine wind-blown material thus transported from the water courses probably forms the great bulk of the soil material known as loess.

Effingham county being some distance removed from a major stream valley did not receive a very thick deposit of loess. It varies in thickness from a few inches to not more than three feet. Most of this loess was deposited during two different interglacial periods, the earlier known as the Sangamon, and the later as the Peorian. Between the time of the drift deposit and that of the loess enough time elapsed that soil was formed from the drift. These old drift soils were buried by the loess and their relation to the present surface soils will be pointed out later.

Process of Soil Development

Soils are not formed all at once; they develop gradually as the result of many forces acting on such parent material as loess, drift, or solid rock. When first deposited, the composition of the soil material, especially of loess, is rather uniform thruout. As time goes on, however, the weathering forces, such as freezing and thawing and wetting and drying, serve to break down the rock particles into finer particles; chemical action renders certain substances soluble; and leaching translocates these substances from one depth to another or else washes them out of the soil altogether. Finer particles are also carried downward by water, and under certain circumstances they accumulate in the subsoil to such an extent as to form an almost impervious stratum.

Organic life, both plant and animal, plays a highly important role in this soil forming process. As the elements of plant food become available, the simpler forms of vegetation, followed by the higher plants, gradually spread over the land.

In Effingham county conditions were favorable for the development of a grass vegetation, the decay of which added much organic matter to the soil. As the weathering process continued, the soils became acid and somewhat impoverished thru the loss of lime and other substances. These soils no longer support the luxuriant vegetative growth that they once did, and the originally dark-colored soils have become gray.

Near the streams, where good drainage has been maintained, forest vegetation has developed, and the trees have been instrumental in reducing the amount of organic matter in the soil. The surface soil under timber vegetation is even lighter colored than prairie soil.

Thus soils are constantly changing in their characteristics; in other words, they undergo an aging process, in a sense similar to that of living beings. Hence soils are spoken of as *youthful, immature,* and *mature,* according to the stage of

development at which they have arrived. Thus in Effingham county, soils on the upland have reached maturity; that is to say, they have been exposed to the weathering process so long that certain characteristics are clearly and definitely expressed. On the other hand, in the bottom land and in eroded areas youthful soils are found because the soil materials have been either deposited in the one case, or uncovered in the other, so recently that the transforming processes have had little time to act.

One of the most pronounced effects of the process of soil development is the gradual stratification of the material into layers, or "horizons." Differences in the arrangement, thickness, and nature of these horizons constitutes one of the chief characteristics for separating soils into types.

For the purposes of this report soil types will usually be described according to the outstanding characteristics of their strata designated as *surface, subsurface,* and *subsoil.* The surface layer is the upper 3 to 10 inches; it is that part of the soil that is cultivated and in which the most roots are found. The subsurface lies just below the surface and it is usually lighter in color than the surface. The subsoil begins at depths varying from 12 to 24 inches; it has two divisions, the upper one being more compact and plastic than any other layer. The lower subsoil is the more friable and the yellowish tinge is more pronounced.

THE SOIL MAP

Basis of Soil Classification

In the soil survey the "type" is the unit of classification. Each soil type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or horizons, which constitute the soil profile in all mature soils. Among these characteristics may be mentioned color, structure, texture, and chemical composition. The topography and the kind and character of the vegetation are easily observed features of the landscape which are very useful indicators of soil character. A knowledge of the geological origin and formation of the soil material of the region being mapped often makes possible an understanding of the soil conditions which occur.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Naming the Soil Types

In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a somewhat definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive; on the contrary, the profile of mature soils is usually made up of more than one

stratum and it is impossible to describe each stratum in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

FIG. 7.—STUDYING THE SOIL PROFILE
Deep natural exposures are made use of in studying the soil profile.

To assist in designating soil types, a number is assigned to each type. These numbers are not only a convenience in referring to the respective types but they are especially useful in designating very small areas on the map and as a check in reading the map colors.

TABLE 1.—SOIL TYPES OF EFFINGHAM COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
2	Gray Silt Loam On Tight Clay	215.12	137 677	45.84
3	Gray Silt Loam On Orange-Mottled Tight Clay	40.21	25 734	8.57
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	.31	198	.07
10	Deep Gray Silt Loam	4.46	2 855	.95
46	Grayish Brown Silt Loam On Clay	1.46	934	.31
48	Grayish Drab Silt Loam On Clay	4.43	2 835	.94
11	Light Gray Silt Loam On Tight Clay	.85	544	.18
12	Yellow-Gray Silt Loam On Tight Clay	25.04	16 026	5.33
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	89.81	57 479	19.13
14	Reddish Yellow-Gray Silt Loam	.37	237	.08
8	Eroded Gravelly Loam	45.25	28 960	9.64
120	Slick Spots	3.97	2 541	.85
72	Mixed Loam	38.07	24 365	8.11
	Total	469.35	300 384	100.00

Table 1 gives the list of the soil types as mapped in Effingham county, the area of each in square miles as well as in acres, and also the percentage that each type constitutes of the total area of the county.

The accompanying colored map, shown in two sections, gives the location and boundary of each soil type and indicates the position of streams, roads, railroads, and town sites.

DESCRIPTION OF SOIL TYPES

Based on the principles explained above, the soils of Effingham county have been differentiated under nineteen soil types. A brief description of the outstanding characters, together with a few suggestions for the practical management of each type, are given in the following paragraphs.

Gray Silt Loam On Tight Clay (2)

Gray Silt Loam On Tight Clay is found on the poorly drained, flat to gently undulating upland. It comprizes nearly one-half of the area of the county as mapped. It is cold and wet in spring, and often drouthy in summer. It was developed under a prairie-grass vegetation. The type is characterized by an almost impervious subsoil.

The surface soil is 7 to 8 inches thick and is a friable gray silt loam. The subsurface has two divisions, the upper being somewhat like the surface soil except lighter in color, and the lower an ashy, light gray silt loam. The subsoil begins at 18 to 22 inches and is a tough, plastic clay, pale yellowish gray in color. It remains tight and slowly pervious to depths of 60 to 70 inches. Pale red or orange spots frequently occur near the top of the subsoil. The material becomes somewhat sandy and contains a few pebbles below 30 to 36 inches. This type contains many Slick Spots, or scalds, the areas of which are often too small to designate on the map. For description and management of these areas, the reader is referred to the discussion of Slick Spots (page 18).

Management.—This type is naturally very poorly drained, and the practical impossibility of securing adequate artificial drainage makes it questionable just how far to proceed in treatment to increase production. Tile will not draw and open surface ditching is the only means of drainage. In order to be effective the ditches must be placed 2 to 4 rods apart, the slope must be sufficient for drainage, and a good outlet must be established.

The soil is low in organic matter and is strongly acid. Limestone should be added and a legume crop grown and turned under. Sweet clover is probably the best legume to use. After the organic-matter content is built up, a trial application of some potassium fertilizer should be made. If such application proves profitable, the treatment may be extended to the whole field. Indications from the results of soil experiment fields located on this soil type are that under the best of treatment the general level of production will not be high and occasional crop failures may be anticipated. Corn should probably not be grown extensively on this type. It is more suitable for hay or pasture and small grain. Alfalfa usually fails. Redtop for seed has been the most profitable crop in recent years.

The results of field experiments at Toledo and at Newton representing this soil type are given on pages 27 and 29.

Gray Silt Loam On Orange-Mottled Tight Clay (3)

Gray Silt Loam On Orange-Mottled Tight Clay is mapped on the undulating to gently rolling prairie areas at the heads of drainage courses and on the low ridges. This type occupies about 40 square miles, or 8.57 percent of the area of the county. It has fair surface drainage and poor underdrainage.

The surface soil is 6 to 7 inches thick and is a friable gray silt loam. The upper subsurface is a yellowish gray, friable silt loam. A thin, ashy, light-gray band forms the lower subsurface soil. The subsoil begins at 14 to 18 inches and its upper part is a very compact, plastic, yellowish gray clay containing orange spots. The lower subsoil, below 28 to 30 inches, contains some sand, a few pebbles, and is not so tight as the upper subsoil. It is pale yellowish gray in color, becoming more intensely yellowish with increasing depth.

Management.—This type, even tho it occurs on land with a slight slope, is poorly drained. Every precaution should be used to get the excess surface water removed during wet seasons. Open surface ditches at frequent intervals will accomplish this if proper outlets are established. Tile cannot be used successfully because the water cannot get into them thru the tight subsoil. Following the correction of drainage conditions, deficiencies in organic matter should be taken care of as suggested under the management of Gray Silt Loam On Tight Clay (page 13). The results from the Ewing experiment field, Series 100 and 200 of which are located on this type, indicate that the use of potassium fertilizer would pay. With full soil treatment, good yields have been obtained on this field. For further discussion of these experiments see pages 30 to 32.

Yellowish Gray Silt Loam On Orange-Mottled Tight Clay (4)

Two areas of Yellowish Gray Silt Loam On Orange-Mottled Tight Clay are found in the northwestern part of Effingham county. The type occupies only .31 of a square mile. It occurs on rolling prairie land and is well drained.

The surface soil is 5 to 6 inches thick and is a yellowish gray silt loam. The subsurface is friable and yellow with a reddish cast. The subsoil begins at 11 to 14 inches and is a medium-compact grayish yellow clay loam. The upper few inches have a distinct reddish cast, this coloration appearing in the form of splotches. Sand and gravel frequently occur below 20 to 25 inches. The material becomes friable below 30 inches.

Management.—Because of the slope of the land on which this type is developed, surface drainage is good. In fact, precaution must be observed in keeping the land covered with vegetation during winter and early spring in order to avoid erosion. The organic-matter content should be increased by applying limestone and growing and turning under legume crops. Increasing the organic-matter content will enable the soil to absorb more water and thus reduce erosion. On the steeper slopes terracing should be used as a means of checking erosion. This soil type makes good orchard land and is well adapted to small fruits and

vegetables. Alfalfa can be successfully grown if the acidity of the soil is corrected. The yield of corn is often cut by drouthy conditions in summer, but small grains, particularly winter wheat, usually yield a good crop. A trial application of a phosphate fertilizer should be made following the increase of organic matter in the soil.

Deep Gray Silt Loam (10)

Deep Gray Silt Loam occurs in depressions at the heads of drainage courses and at the bases of long, gradual slopes. The type occupies only 4.46 square miles, slightly less than 1 percent of the total area of the county. It is fairly well drained but because of its topographic position is subject to an accumulation of run-off from higher land. The run-off brings in some sediment which is being continually deposited on the original surface.

The surface soil varies from 8 to 12 inches in thickness and is a friable gray silt loam. The subsurface is lighter in color than the surface, becoming light gray below 20 inches. The subsoil in many places is undeveloped or only faintly developed. Usually the light gray silt loam carries down to considerable depth. Where a subsoil is developed it is a pale yellowish gray clay loam, medium-compact and plastic. The subsoil is seldom more than 10 inches thick and always lies below 22 inches.

Management.—Deep Gray Silt Loam can be fairly well drained by a system of deep surface-ditching emptying into a proper outlet. Tile will work to advantage in some places. Where tile are used they should be kept either above or near the top of the subsoil. Regular additions of fresh organic matter should be made. This entails liming and the growing and turning-under of legumes. Sweet clover is probably the best legume to use because it will withstand the excessive moisture during winter and early spring better than some other legumes. A trial application of a potassium fertilizer following the incorporation of organic matter is suggested. This type, properly managed, is one of the best upland soils in the county when used for the production of grains, especially corn.

Grayish Brown Silt Loam On Clay (46)

Grayish Brown Silt Loam On Clay occurs in depressional areas in the upland prairie. It was swampy or covered with water long after the surrounding land was cultivated. It is a young soil as a result of having been covered with water for such a long time. It occupies only 1.46 square miles in the county.

The surface soil, 10 to 11 inches thick, is a heavy, dark grayish brown silt loam. The subsurface is a brownish yellow silt loam which becomes decidedly grayish near the base. The subsoil begins at 19 to 21 inches and is a medium-compact and plastic pale drabbish gray clay loam. It becomes less compact and more grayish with depth.

Management.—Grayish Brown Silt Loam On Clay can be made the most productive upland soil in Effingham county by thoro draining. Tile should be installed at close intervals and a good outlet established. A deep open ditch constructed thru this soil type to a stream outlet would probably pay. Altho

this soil contains considerable organic matter, provision should be made to renew the supply frequently. This involves the application of limestone and the growing and turning-under of legumes. A legume crop should be grown on the land at least once in four years. One of the phosphate fertilizers should be applied as a trial following the limestone-legume program. Following proper treatment a regular rotation including corn and small grain should prove successful.

Grayish Drab Silt Loam On Clay (48)

Grayish Drab Silt Loam On Clay is found in association with the type Grayish Brown Silt Loam On Clay just described, and represents the next step in the aging of this type. It occupies 4.43 square miles in the county.

The surface soil, 9 to 10 inches thick, is a friable, grayish drab silt loam. The subsurface is gray, becoming rather ashy at the base. The subsoil begins at 18 to 22 inches and is a pale yellowish gray compact and plastic clay. It gradually becomes less compact with increasing depth.

Management.—This type should be managed in a manner similar to that suggested for Grayish Brown Silt Loam On Clay. It is, however, more difficult to drain, more acid, and not quite so productive. Properly managed, however, it is a productive soil.

Light Gray Silt Loam On Tight Clay (11)

Light Gray Silt Loam On Tight Clay occupies the very flat, exceptionally poorly drained tracts in the upland timber area. It is the poorest soil in the county but fortunately it covers only .85 of a square mile.

The surface soil, a light yellowish gray silt loam, is only 3 to 4 inches thick. The upper subsurface down to about 15 inches is a light gray silt loam. The lower subsurface is an ashy, white silt loam. The subsoil begins at 20 to 24 inches and is a very compact, plastic, and almost impervious clay.

Management.—It is practically impossible to drain this soil adequately, and because of the drainage handicap it is doubtful whether any sort of treatment involving a money outlay is advisable at this time. The land can best be seeded in redtop and kept in meadow. Experiments on the Sparta field described on pages 32 and 33 have shown some response to soil treatment, but the drainage on this location is somewhat better than that of the type in general. Moreover, even under the most favorable treatment the level of production is still so low as to make the farming of this land a doubtful enterprise.

Yellow-Gray Silt Loam On Tight Clay (12)

Yellow-Gray Silt Loam On Tight Clay occurs on flat to very gently sloping land which is now, or was formerly, timbered. It covers about 25 square miles of the county. Both the surface drainage and underdrainage are poor. Slick Spots are numerous, and in many respects this timber soil resembles the prairie type Gray Silt Loam On Tight Clay.

The surface soil, which is 4 to 5 inches thick, is a yellowish gray silt loam. The subsurface is lighter than the surface, becoming ashy white below fifteen

inches. The subsoil is a very compact, plastic, almost impervious, pale yellowish gray clay.

Management.—Because of the similarity of the two types the suggestions offered for the management of Gray Silt Loam On Tight Clay (page 13) will also apply, in the main, to this type, Yellow-Gray Silt Loam On Tight Clay, altho the latter demands somewhat more attention to the maintenance of organic matter. Usually on the latter type drainage can be better provided because it lies nearer a good outlet. For the behavior of this land under soil treatment the reader is referred to the account of the Raleigh field, pages 33 to 35.

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay (13)

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay is mapped on the intermediate sloping land which is now or was formerly timbered. It lies for the most part between the flat prairie upland and the steep gullied land along streams. This type occupies about 90 square miles, nearly one-fifth of the total area of the county. It has fair to good surface drainage and fair underdrainage.

The surface soil, which is about 6 inches thick, is a friable, yellowish gray silt loam. The color of the upper subsurface is grayish yellow, and of the lower subsurface, light gray. The subsoil begins at 15 to 18 inches and is a grayish yellow, medium-compact and plastic clay. Some sand and small gravel appear in the material below 30 inches, and it becomes less compact below 36 to 40 inches.

Management.—Artificial drainage must be provided on this type either by tiling or by open surface-ditching. Tile should be placed not over 4 rods apart and even closer together on the flatter areas. Open surface-ditching is the more practical means of draining, provided the ditches are so made as to avoid erosion. The soil should not be left without a protective vegetative cover in the winter and spring, for sheet erosion will do considerable harm. Fresh organic matter should be provided frequently thru the limestone-legume program. A legume should be grown and plowed under every three or four years. Trial applications of both phosphorus and potassium fertilizers are suggested. This soil responds well to good farming, and following proper treatment should produce satisfactory yields of the common grain crops.

Reddish Yellow-Gray Silt Loam (14)

Reddish Yellow-Gray Silt Loam occurs on the rolling timbered upland. Only a few areas of this type are mapped in Effingham county, all being along the Little Wabash river. The type occupies only .31 of a square mile.

The surface soil is 5 to 6 inches thick and is a friable, brownish yellow silt loam. The subsurface is yellow with a reddish cast. The subsoil begins at 11 to 14 inches and is a loose, open, reddish yellow silt loam.

Management.—Natural drainage is good, but when the soil is cultivated provision must be made to protect the land from erosion. Terraces should be constructed to provide this protection. The soil needs regular additions of organic matter, which can be provided thru a limestone-legume program. Phosphate fertilization should bring a good return, particularly if wheat is grown.

Alfalfa will grow well on this land following liming. The yield of corn is often cut by summer drouths. This soil type is excellent for orchards, small fruits, and vegetables.

Eroded Gravelly Loam (8)

Eroded Gravelly Loam is mapped on the steep, gullied hillsides which lie adjacent to stream bottom lands. The type occupies about 45 square miles, slightly less than 10 percent of the total area of the county. All of this type of land is subject to destructive erosion. Most of this land has never been cleared of timber. Wherever it has been cleared, erosion soon destroyed the land for cultivation. On the lower slopes a few outcrops of rock occur in the northern part of the county.

Eroded Gravelly Loam has little or no true soil development because the surface is removed faster than the soil forms. The material is a sandy, gravelly, clayey mass, and on the steeper slopes it is calcareous. Erosion has exposed the unleached glacial drift in these calcareous places.

Management.—This soil type cannot be cultivated because erosion removes the surface material within a year or two when exposed. Some of the less steep areas could be used for orcharding or permanent pasture. A vegetative cover must be kept on the land continuously. This land should be left in timber; if it has been cleared it should be replanted with trees or else put into permanent pasture.

Slick Spots (120)

Slick Spots are found in association with upland soil types developed on flat to gently undulating topography. The majority of these Slick Spots occur as small spots within the types Gray Silt Loam On Tight Clay and Yellow-Gray Silt Loam On Tight Clay and are too small to map. Most of the areas that are shown on the map are found near the heads of drainage courses, where erosion has washed off the surface soil and exposed the subsoil, thereby making the Slick Spots readily discernible. In the fields they can be identified by their lighter colored surface and their differing moisture condition from those of the surrounding soil. Once dry, as in summer, they do not absorb water readily and are always drier than surrounding soil, but upon becoming thoroly soaked they absorb water readily and offer little resistance to pressure. Most of the bad mud holes in the roads develop on these spots. In plowing, the hard, compact subsoil tends to throw the plow out of the ground. When the surface soil is washed away, a Slick Spot can be recognized by the light greenish gray or pale yellowish gray subsoil color. When the subsoil dries it becomes very hard and in profile section it stands out in distinct columns.

Slick Spots develop where the leaching of materials, chemically known as bases, from the layer of loess above is arrested by the presence of a slowly pervious layer formed in the drift below. These bases are thrown out of solution as the water evaporates; they accumulate in the soil, thus bringing about an alkaline condition. This accumulation produces an excess of soluble salts, which either unbalances plant-food conditions or else actually produces toxic conditions for plant growth.

The surface soil may be described as being 5 to 7 inches thick, light gray in color, and of a friable silt loam texture. The subsurface when present is an ashy, white silt loam. The subsoil, beginning at depths varying from 6 to 20 inches, is a tough, sticky clay, light greenish gray or pale yellowish gray in color. When dry it is very hard, but when wet it is easily penetrated.

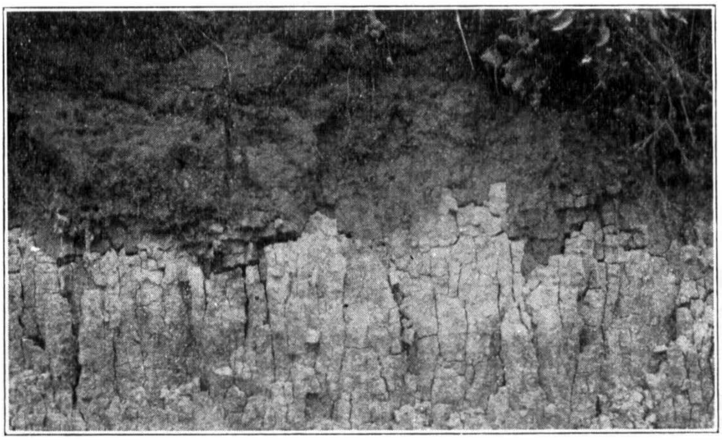

FIG. 8.—COLUMNAR STRUCTURE IN SUBSOIL OF SLICK SPOT

This distinctly columnar formation occurs just beneath the surface horizons in Slick Spot areas.

Management.—For Slick Spots drainage should be provided when possible, so that water will not accumulate in the soil above the 30-inch depth. Where drainage cannot be provided, no attempt at treatment should be made. If the surface soil is acid, as it usually is, enough limestone should be applied to enable sweet clover to grow. The sweet clover may be allowed to reseed itself for several years and then be plowed under. No further treatment can be suggested at this time. Practical experience has shown that animal manure does not pay so well when placed on these spots as it does when used on the types in which these spots occur. Crop yields on these spots vary from nothing in unfavorable years to a small yield in a season when the moisture is just right.

Mixed Loam (72)

Mixed Loam is mapped on the overflow lands along streams. It occupies about 38 square miles in Effingham county. The streams overflow after each heavy rain and are continually depositing material brought down from surrounding higher land or from upstream areas. The soil material is for the most part silty but in places contains some sand and gravel. On account of the continual deposit of new soil material, true soil development has not taken place and the soil is therefore said to be youthful.

The surface 8 to 12 inches is usually darker in color than the material below it. In the broad bottom land of Little Wabash river there are some places which receive little or no deposit. In these places some compaction is noticeable between 20 and 30 inches, indicating that the subsoil has begun its development.

The soil of the larger bottom lands are generally gray in color while that of the smaller ones is a yellowish gray.

Management.—Altho Mixed Loam is subject to frequent overflow, most of these inundations take place in early spring or late fall, giving enough time to mature a crop of corn, soybeans, or cowpeas. Small grain crops are frequently drowned out, as are also clovers and grass for hay. The soil is slightly acid, but unless it is protected from overflow, no treatment is suggested. Tile and surface ditches can be used for draining this land.

CHEMICAL COMPOSITION OF EFFINGHAM COUNTY SOILS

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as explained above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

Organic Matter and Nitrogen Generally Low

Considering first the surface soils, it will be observed from Table 2 that with the exception of Types 4 and 46, which occupy very small areas, the soils of Effingham county are generally somewhat low in their content of organic matter and nitrogen. The organic carbon, which constitutes about 50 percent of the organic matter and which is used as a measure of organic matter, varies for the most part between 15,000 and 30,000 pounds an acre in the surface soil. The nitrogen content runs parallel to that of carbon, being from one-ninth to one-tenth as high. This relationship is explained by the fact that nearly all the soil nitrogen (usually more than 99 percent) is organic nitrogen, that is, it is a

TABLE 2.—EFFINGHAM COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
2	Gray Silt Loam On Tight Clay	23 290	2 380	720	630	23 990	6 430	7 840
3	Gray Silt Loam On Orange-Mottled Tight Clay..........	27 640	2 980	930	670	21 330	4 280	4 560
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay ..	37 400	3 960	1 100	1 000	27 520	4 600	5 420
10	Deep Gray Silt Loam..........	23 710	2 610	800	800	20 570	3 220	3 630
46	Grayish Brown Silt Loam On Clay.......................	35 410	3 670	780	910	26 540	3 870	9 170
48	Grayish Drab Silt Loam On Clay.......................	29 580	3 090	570	470	28 700	3 630	8 870
11	Light Gray Silt Loam On Tight Clay..	18 070	2 050	630	470	21 720	4 150	4 770
12	Yellow-Gray Silt Loam On Tight Clay................	15 410	1 490	460	590	26 210	3 270	4 160
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	22 660	2 270	590	530	28 660	3 920	3 780
14	Reddish Yellow-Gray Silt Loam	18 150	1 730	560	510	31 450	3 060	4 310
8	Eroded Gravelly Loam[1]........	....	.....	.....	.....	....	....	....
120	Slick Spots.........	20 700	2 580	710	850	20 820	4 220	5 030
72	Mixed Loam[1]................	....	.....	.....	.....	....	....	....

[1]No samples were collected representing Types 8 and 72 on account of the heterogeneous character of these soils.

part of the organic matter. The ratio of nitrogen to carbon varies to some extent in different soil types, being wider in younger soils and those particularly high in organic matter, where it may be as wide as 1 to 12 or 1 to 14 or even wider. The reason for this is that the carbon is lost more rapidly than the nitrogen as decay proceeds, leaving a gradually increasing proportion of nitrogen to carbon in the soil, even tho the amount is actually being reduced. One of the important biological processes associated with the decay of organic matter is the conversion of the organic nitrogen into the inorganic form of nitrate, the form most readily used by plants, and into ammonia, a form less readily used but nevertheless utilized to some extent by some crops.

It will also be observed in Tables 3 and 4 that the nitrogen-carbon ratio narrows very perceptibly in the middle stratum and to a still greater extent in the lower, the values here ranging between 1 to 4.2 and 1 to 6.9. The narrowing of this ratio with increasing depth may be observed in most soil types, but is most pronounced in those which are mature, as is the case with most of the soils in this county. The reason is to be found in the fact that the organic matter in the deeper levels is older and is replenished with fresh vegetable matter to a less extent than is that nearer the surface.

Phosphorus and Sulfur Less Closely Associated With Organic Matter

Two other chemical elements, phosphorus and sulfur, both essential for plant growth, are associated with the soil organic matter, tho to a less extent than is nitrogen. From one-fourth to one-third of the total phosphorus in mineral soils exists as organic phosphorus as a rule. The proportion is higher in soils high

TABLE 3.—EFFINGHAM COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
2	Gray Silt Loam On Tight Clay	20 410	2 480	1 110	830	51 320	8 880	11 400
3	Gray Silt Loam On Orange-Mottled Tight Clay	17 000	2 730	1 060	950	48 500	13 620	9 360
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	28 050	4 250	1 540	1 280	57 890	15 390	8 670
10	Deep Gray Silt Loam	18 350	3 130	1 320	960	48 570	6 930	9 020
46	Grayish Brown Silt Loam On Clay	32 910	3 560	1 500	1 460	53 940	10 450	20 660
48	Grayish Drab Silt Loam On Clay	29 590	3 800	1 190	1 180	61 710	7 200	20 810
11	Light Gray Silt Loam On Tight Clay	11 730	1 950	1 040	580	41 460	10 740	8 240
12	Yellow-Gray Silt Loam On Tight Clay	11 830	1 290	780	770	54 940	8 640	7 170
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	10 940	1 880	1 140	1 010	64 540	12 410	8 890
14	Reddish Yellow-Gray Silt Loam	10 570	1 690	1 210	1 220	64 930	12 450	12 050
8	Eroded Gravelly Loam[1]	......	......	......	......	......	......	......
120	Slick Spots	18 850	2 740	1 240	890	49 610	16 270	12 640
72	Mixed Loam[1]	......	......	......	......	......	......	......

[1]No samples were collected representing Types 8 and 72 on account of the heterogeneous character of these soils.

in organic matter, and hence a closer relationship between the two may be observed. In soils at the organic-matter level of the majority of the Effingham county types, the organic phosphorus constitutes probably less than one-fourth of the total phosphorus. In the soils of this county the sulfur content is, on the whole, somewhat lower than that of phosphorus. Type 4, with the highest organic-matter content, also has the largest amounts of phosphorus and sulfur. Further than this the relationship between these elements and organic matter is not pronounced.

While crops in general take as much sulfur as phosphorus from the soil, sulfur deficiencies do not ordinarily develop because of the atmospheric supply. The sulfur dioxid which escapes into the air in the burning of wood and coal is brought to the earth dissolved in rain water, the amount added to the soil ranging in different parts of the state from one to three or more pounds of sulfur an acre a month.

Potassium Content Comparatively Uniform

The potassium content of Effingham county soils shows relatively less variation from type to type than any other element studied. The average amount in the surface soil is approximately 25,000 pounds an acre, and the entire range thru all the types in the county is from a minimum of 20,820 pounds up to 31,450 pounds an acre. The potassium concentration in the soil at different depths likewise shows very little variation, averaging 27,150 pounds an acre in the middle stratum and 26,530 pounds in the lower when the figures are converted to the basis of 2 million pounds an acre.

TABLE 4.—EFFINGHAM COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
2	Gray Silt Loam On Tight Clay	16 370	2 870	1 780	1 110	78 490	17 460	21 850
3	Gray Silt Loam On Orange-Mottled Tight Clay..........	22 870	3 340	1 320	1 860	71 130	22 430	12 370
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay ..	18 830	2 930	1 850	1 830	100 490	29 070	17 320
10	Deep Gray Silt Loam..........	14 040	2 870	1 750	800	75 130	17 320	14 010
46	Grayish Brown Silt Loam On Clay......................	15 130	2 680	1 850	2 120	73 050	15 950	32 780
48	Grayish Drab Silt Loam On Clay......................	15 350	2 620	1 770	1 720	84 230	14 960	34 030
11	Light Gray Silt Loam On Tight Clay......................	7 220	1 710	1 690	580	59 360	21 580	9 870
12	Yellow-Gray Silt Loam On Tight Clay................	10 580	1 690	1 420	760	83 640	27 620	14 970
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	8 300	1 560	1 670	1 370	86 320	17 950	14 550
14	Reddish Yellow-Gray Silt Loam	10 190	1 820	1 770	1 550	78 860	19 660	25 680
8	Eroded Gravelly Loam[1]........	......	......	......	......	......	......	......
120	Slick Spots...................	7 760	1 830	2 250	830	84 710	26 750	30 770
72	Mixed Loam[1]................	......	......	......	......	......	......	......

[1]No samples were collected representing Types 8 and 72 on account of the heterogeneous character of these soils.

Wide Variations in Calcium and Magnesium

The variations in the calcium and magnesium content of Effingham county soils are almost as great as those in the organic matter. These two elements, particularly calcium, are of special interest because of the relation which they bear to the lime-requirement of soils. Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms, calcium-aluminum silicates, replaceable calcium, and calcium carbonate. *Calcium-aluminum silicates* are complex soil minerals which decompose but slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Calcium may be deficient as a plant-food element in such soils, so that the satisfying of this need may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), by which it is absorbed; this is known as *replaceable calcium,* and is much more easily obtainable by growing plants than the mineral form above mentioned. It is found more abundantly in the soils which are nonacid or only slightly acid. Soil types are occasionally found that grow sweet clover luxuriantly because of the abundance of replaceable calcium which they contain, even tho they may be actually acid. *Calcium carbonate,* the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Of the three forms of calcium this is the most readily dissolved in the soil water and removed in the drainage water, tending to accumulate at lower and lower depths as leaching proceeds. The extent of this leaching process in Effingham county has been

such that all the calcium carbonate has been removed from the surface soil, and in practically all of the soils it has been removed to a depth greater than 40 inches.

Even after the carbonates have disappeared there continues a gradual release of the replaceable calcium and magnesium, which are continually being carried down by the soil water. As this process goes on, magnesium tends to be absorbed by the soil colloids more readily than calcium, so that with increasing depth there is an increasing proportion of magnesium to calcium. This change is more pronounced in the mature soils. For example, in Type 11 the ratios of the magnesium to calcium in the upper, middle, and lower strata, are, respectively, .87, 1.30, and 2.19, as may readily be computed from Tables 2, 3, and 4. That is, in the surface soil there is only about seven-eighths as much magnesium as calcium, in the middle stratum there is about one and a third times as much, while in the lower stratum, 20 to 40 inches, the magnesium is more than double the calcium. Type 46 illustrates the condition in a more youthful soil, in which the weathering and leaching have not been sufficient to bring about these changes in the magnesium-calcium ratio. Consequently the ratios of magnesium to calcium are about the same at all three depths sampled, namely, .42, .50, and .49.

From these observations it is obvious that some of the various processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, are related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or of the acidity of a given soil type because, while some samples will contain calcium in the form of carbonate (few if any such areas are to be found in Effingham county), others will not only contain no calcium but may actually have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and they give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests therefore furnish the basis for some general recommendations which are given in the descriptions of the soil types on pages 13 to 20. To have a sound basis for the application of limestone the owner or operator of a farm will usually find it desirable to determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 41) is pertinent and should be read in this connection.

Character of Chemical Combination Related to Availability

It has been seen that a given plant-food element exists in the soil in various forms, or chemical combinations. Thus the soil phosphorus is partly organic and partly in several different inorganic or mineral combinations. These differ from each other in the rates at which they become available to growing crops. Again calcium has been observed to be present sometimes as *calcium carbonate,* which is quickly available in the soil, but is usually more abundantly present as *replaceable calcium,* a form which is less active yet more or less available; and also as *calcium-alumino-silicate* minerals which are decomposed very slowly. Statements of similar import might be made concerning nitrogen, sulfur, and other elements. Moreover, the proportions in which the different forms of a given element occur vary in different soils. In the light of these facts it becomes apparent that altho a knowledge of the total amounts of these various elements present in the soil is of interest, this knowledge alone does not usually furnish sufficient information to determine completely the fertilizer requirements of a soil.

Service of Chemical Investigations in Soil Improvement

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways. In the first place, they reveal at once outstanding deficiencies or other chemical characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual composition are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as indicating a corresponding difference in response to phosphate fertilization. Again, 100 pounds to the acre of active nitrogen added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen. An example of the direct use of the results of chemical investigations is the discovery of the marked shortage of potassium in peat soils and consequently the need for potassium fertilizers.

The second use of chemical methods is in the more detailed study of soils. The processes of soil development leave their imprint upon the soil both in its physical conformation and also in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value, fertility needs, and response to treatment.

FIELD EXPERIMENTS ON SOIL TYPES SIMILAR TO THOSE IN EFFINGHAM COUNTY

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described above.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a given plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots

have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

In the presentation of the data much use is made of the following symbols:

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

TOLEDO FIELD

The Toledo experiment field is located on Gray Silt Loam On Tight Clay immediately south of Toledo in Cumberland county. It was established in 1913. This field of 17 acres is laid out into two separate systems of plots, one including four series of 10 plots each, and the other containing four series of 4 plots each, and designated as the Major and the Minor series respectively.

Major Series

The system of plots made up of Series 100, 200, 300, and 400 is under a crop rotation of wheat, corn, oats, and clover. Cowpeas were seeded in the corn at the last cultivation until 1921, when this practice was abandoned. In 1922 sweet clover was introduced as the regular clover crop, but since 1926 a mixture of clovers, alfalfa, and timothy has been used. After the plots had received a total of 6½ to 8 tons of limestone an acre on the different series, application

TABLE 5.—TOLEDO FIELD: SUMMARY OF CROP YIELDS
Average annual yields 1914-1929—bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat 12 crops	Corn 16 crops	Oats 15 crops	Clover[1] 8 crops	Sweet clover 3 crops	Soybeans 3 crops
1	0	9.0	21.0	15.2	(.23)	.11	(.70)
2	M	10.7	27.7	18.8	(.40)	.24	(.72)
3	ML	22.2	40.5	30.3	(1.37)	2.45	(1.27)
4	MLP	23.2	40.0	30.6	(1.40)	2.42	(1.21)
5	0	8.1	16.9	14.8	(.17)	.26	(.38)
6	R	9.4	19.1	16.3	(.32)	.53	(.47)
7	RL	20.8	27.5	32.6	(1.41)	1.84	(.94)
8	RLP	23.4	28.1	32.4	(1.59)	1.77	(1.05)
9	RLPK	28.0	41.0	35.8	(1.92)	2.48	(1.18)
10	0	6.7	14.8	15.9	(.22)	.19	(.53)

[1]Including three crops of mixed hay.

of this material was suspended in 1922 until further need for it becomes apparent. In 1923 the return of the wheat straw on the residues plots was discontinued.

Table 5 presents a summary of the crop yields including the years in which the complete plot treatments have been in effect. The results confirm those of other fields located on similar soil and, briefly stated, they show:

1. Low yields on untreated land.
2. Only a slight response to organic manures without limestone.
3. A very decided response to the use of limestone in connection with organic manures.
4. A limited response to rock phosphate applied with organic manures and limestone but not sufficient to cover the cost of material.
5. A general response to potassium fertilizer, the response becoming very marked in the case of the corn. In fact, the kainit, which supplies the potassium, is being used with good profit.

Minor Series

The second set of plots on the Toledo field, comprizing Series 500, 600, 700, and 800, has been devoted mainly to an investigation in soil tillage, the purpose being to compare the effects of subsoiling, deep tilling, and dynamiting with that of ordinary plowing. A crop rotation of corn, soybeans, wheat, and sweet

TABLE 6.—TOLEDO FIELD: TILLAGE EXPERIMENTS
Average annual yields 1913-1922—bushels per acre

Tillage treatment	Corn 9 crops	Soybeans 7 crops	Wheat 6 crops	Sweet-clover seed 6 crops
Plowed 7 inches deep	40.2	16.3	13.5	3.68
Subsoiled 14 inches deep	41.9	16.2	12.9	3.65
Deep-tilled 14 inches	37.4	15.2	10.8	3.18
Dynamited	40.3	16.4	11.7	4.25

clover was adopted, second-year sweet-clover stubble being plowed late in the fall for corn. An application of 4 tons of limestone an acre was made on all plots in 1913; 3 tons were applied for the 1917 crop, and 2 tons for the 1921 crop. One ton of rock phosphate was applied in the fall of 1914, and again in the fall of 1918.

A summary of the crop yields is given in Table 6. For a detailed account of these experiments the reader is referred to Bulletin 258 of this Station, "Experiments with Subsoiling, Deep Tilling, and Dynamiting."

The conclusions reached from the results of these experiments is that none of the special tillage treatments had any superior beneficial effect on crop yields. Deep tilling apparently decreased yields, probably because of the mixing of subsurface and subsoil with the surface soil.

NEWTON FIELD

A 30-acre experiment field has been maintained by the University at Newton in Jasper county since 1912. The soil type has been mapped as Gray Silt Loam On Tight Clay but the field is not altogether uniform, as is shown by variations in the crop yields. The land is almost level. A system of tile was installed but owing to the impervious nature of the subsoil, the tile did not materially improve the drainage until the scheme was devised of using the tiles as sewers to carry away the surplus water conducted to them thru a system of ditches and catch basins.

The field is laid off into 12 series of plots and these series now make up three separate combinations or plot systems, only one of which will be considered here.

At present a rotation of corn, mixed hay, wheat, and oats is being practiced on Series 100, 200, 300, and 400. Soybeans were formerly grown instead of the mixed hay. Cowpeas have been seeded in the corn and sweet clover in the wheat as catch crops to help supply the organic matter and nitrogen on the residues plots. In 1920 the use of the cowpea catch crop was discontinued, as was also the return of wheat straw in 1922.

The limestone used on these series has been of the dolomitic form ground sufficiently fine to pass a 10-mesh sieve. The usual large initial amount of limestone was not applied here. Up to 1922 the different series had received 5 to 6 tons an acre, when the regular applications were suspended until further need for lime becomes apparent.

Table 7 gives a summary of the crop yields obtained, including the years that the respective complete soil treatments have been in effect.

The results of these experiments are characteristic of those of other fields located on this soil type. They demonstrate again the necessity of liming these acid soils as the foundation for soil improvement. Without lime, legumes fail completely; the use of manure alone is practically ineffective. Phosphorus in combination with lime and organic manure has, as usual, materially benefited the wheat but, in the manner used in these experiments, the rock phosphate has not paid for itself. An increase in yield of all crops excepting oats has

followed the use of potassium fertilizer. The money value of this increase is now sufficient to return some profit on the investment.

Altho the above results show very large percentage increases for proper soil treatment, particularly for liming, yet with the best yields obtained the total production is not very high. The rather simple cropping system serves the purpose of bringing out the possibilities of improving this soil but doubtless more profitable systems of farming can be developed by thoughtful planning in which other products are included in the farm output.

FIG. 9.—WITHOUT LIMESTONE SWEET CLOVER REFUSES TO GROW

A photographic record of adjacent plots on the Newton field. At the right where no clover is seen, no limestone has been applied.

TABLE 7.—NEWTON FIELD: SERIES 100, 200, 300, AND 400, SUMMARY OF CROP YIELDS
Average annual yields 1913-1929—bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *22 crops*	Soybeans *17 crops*	Wheat *18 crops*	Oats *3 crops*	Mixed hay *3 crops*	Stubble-clover *2 crops*
1	0.............	9.5	(.61)	.8	9.7	(.74)	(0)
2	M............	15.1	(.83)	2.0	19.6	(.85)	(0)
3	ML...........	26.2	(1.17)	11.3	23.2	(1.77)	(.59)
4	MLP.....	25.8	(1.25)	15.9	23.9	(2.29)	(.88)
5	0.............	9.8	(.58)	1.6	12.7	(.68)	(0)
6	R.............	9.8	(.55)	1.7	13.1	(.75)	(0)
7	RL...........	16.4	(.90)	8.6	21.9	(1.46)	(.34)
8	RLP..........	16.8	(.99)	14.2	23.4	(1.73)	(.52)
9	RLPK.........	22.0	(1.10)	18.6	19.4	(2.28)	(.83)
10	0.......	6.9	(.54)	.9	10.5	(.88)	(0)

EWING FIELD

As representing the soil type Gray Silt Loam On Orange-Mottled Tight Clay, experimental results from a portion of the Ewing field are presented.

The Ewing field is located in Franklin county about a mile northeast of Ewing. It was established in 1910. Altho four distinguishable soil types have

been identified on this field, the 100 and 200 series of plots lie wholly on Gray Silt Loam On Orange-Mottled Tight Clay. This land is nearly level, the drainage is very poor, and the soil is strongly acid. These two series, together with Series 300 and 400, constitute a plot system farmed under a crop rotation of wheat, corn, oats, and clover, but because Series 300 and 400 lie mainly on another soil type, results from these plots will not enter into the present consideration.

The handling of the crops and the soil treatments have been in the main according to the somewhat standard plan described above. Until 1920 cowpeas

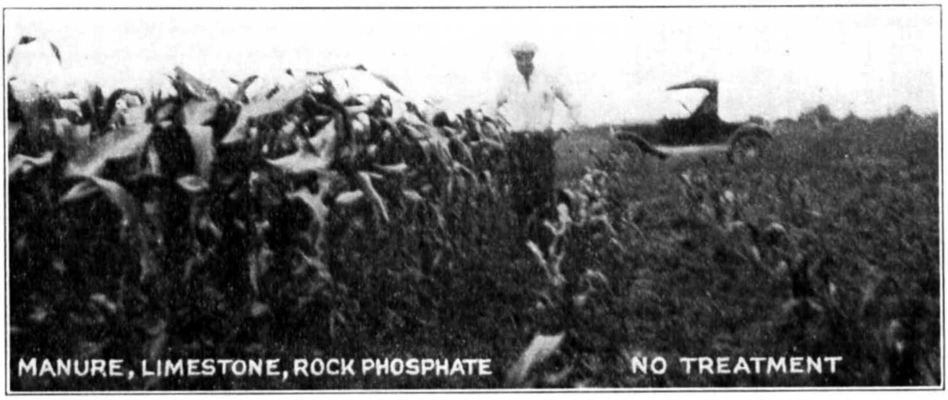

FIG. 10.—CORN GROWING ON NEIGHBORING PLOTS ON THE EWING FIELD IN 1924

At the right is a check plot which produced, as an average of eight years, only 15 bushels of corn an acre; while at the left the plot treated with manure, limestone, and rock phosphate produced 49 bushels an acre as an average for this same period.

were seeded in the corn as a catch crop on the residues plots. From 1921 to 1925 sweet clover served as the regular legume crop, but since that time a mixture of clover, alfalfa, and timothy has been used. In 1922 the limestone applications were discontinued after they had reached a total quantity of 8½ to 10 tons an acre on the different series. No more limestone will be applied until the need for it appears. The return of the wheat straw as a residue was also discontinued at that time. In 1923 the rock phosphate was evened up on all phosphorus plots to 8,500 pounds an acre, and no more will be applied for an indefinite period.

A summary of the results is presented in Table 8, showing the average annual crop yields obtained for the years the plots have been under their complete treatments. The extremely poor yields on the untreated land are characteristic of this soil. About 2.5 bushels of wheat an acre has been the average production on the check plots.

The use of manure alone increases the crop yields somewhat, but not sufficiently to put this kind of farming on a profitable basis. Residues alone are practically without effect.

Limestone produces a very decided increase in yields used either with manure or with residues, the large increase with the latter being due mainly to the successful growth of legumes following the application of limestone. A financial study of these treatments covering the last rotation period reveals the fact that

TABLE 8.—EWING FIELD: SERIES 100 AND 200, SUMMARY OF CROP YIELDS
Average annual yields 1911-1929—bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *8 crops*	Corn *10 crops*	Oats *10 crops*	Clover *1 crop*	Sweet clover *2 crops*	Mixed hay *2 crops*	Soy-beans *4 crops*
1	0	2.3	12.9	8.4	(.20)	0	(.47)	(.46)
2	M	5.2	27.1	14.2	(.24)	0	(.59)	(.54)
3	ML	18.1	49.6	30.6	(.40)	2.23	(1.89)	(1.08)
4	MLP	22.9	50.1	32.8	(.81)	2.25	(2.31)	(1.23)
5	0	2.2	12.2	9.0	0	0	(.60)	(.34)
6	R	1.8	12.3	9.2	0	0	(.69)	(.36)
7	RL	17.5	29.8	27.0	.50	2.46	(1.67)	(.86)
8	RLP	20.2	27.6	27.9	1.08	2.07	(1.64)	(.93)
9	RLPK	28.2	47.6	35.4	.75	2.09	(2.19)	(1.11)
10	0	3.3	16.7	9.9	(0)	0	(.68)	(.56)

manure and limestone is now the most effective combination of the various treatment systems under test. At the prices assumed in the estimate, manure and limestone are returning $19.06 an acre a year in value of crop increases after deducting the cost of the treatment. (See Univ. of Ill. Agr. Exp. Sta. Bul. 347).

The results for rock phosphate are rather peculiar in that they are more favorable in the manure system than in the residues system. This unusual behavior may perhaps be explained by the fact that potassium has become a limiting element on this field and that the manure furnishes a certain amount of this substance.

Potassium fertilizer as used in these experiments has had a very beneficial effect on all the grain crops. In fact, within the last few years the corn crop under the residues system has evidenced acute need for potassium. Thus the average yield of corn for the last five crops under the lime, residues, and phosphorus treatment was 17.9 bushels an acre, while on the adjoining plot with potassium added to the treatment the yield was 48.1 bushels an acre. One year the yield without potassium was 5 bushels an acre while with potassium it was 52.3 bushels.

As mentioned above, the manure-limestone combination is proving the most remunerative treatment on the Ewing field. But unfortunately manure is not abundant. The next best-paying system is the combination of residues, limestone, phosphate, and potash, which returned a net value of $16.31 an acre a year in crop increases.

The recommendation, therefore, for improving land of this type is to apply limestone, use all available farm manure, plow under sweet clover, and return unused crop residues to the soil. Then to this basal program, add potassium and phosphorus as the need for these materials develops.

SPARTA FIELD

As representative of experimental results on the soil type Light Gray Silt Loam On Tight Clay, data from certain plots on the Sparta experiment field are introduced here. This field was established in 1916 in Randolph county immediately north of the town of Sparta. The plots in Series 100, 200, 300, and 400,

TABLE 9.—SPARTA FIELD: SERIES 100, 200, 300, AND 400, SUMMARY OF CROP YIELDS
Average annual yields 1917-1929—bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn 13 crops	Soybeans 12 crops	Wheat 9 crops	Clover 1 crop	Sweet clover 8 crops
1	0	14.9	5.9	4.6	(0)	0
2	M	19.4	7.5	6.8	(0)	0
3	ML	31.0	14.5	15.9	(1.66)	1.87
4	MLP	32.2	14.8	16.6	(1.73)	1.50
5	0	12.5	4.6	4.8	0	0
6	R	16.4	5.5	4.9	0	0
7	RL	26.1	12.8	14.9	1.50	1.40
8	RLP	25.5	13.3	15.7	1.87	1.48
9	RLPK	32.6	14.2	16.5	1.69	2.27
10	0	11.2	4.8	3.9	(0)	0

with the exception of parts of two plots, are all on the soil type mapped as Light Gray Silt Loam On Tight Clay.

These plots are under a crop rotation of corn, soybeans, wheat, and clover (chiefly sweet clover). Until 1921 it was the practice to seed cowpeas as a cover crop in the corn on the residues plots. The soil treatments are as indicated in the accompanying table, and they have been applied in the manner previously described, pages 26 and 27, with the exception that the initial application of limestone was 5 tons an acre. In 1922 the periodic application of this material was discontinued until its further need should become apparent.

Table 9 gives a summary of the results from this field, showing the average annual yields for the different kinds of crops, including the years that the complete soil treatments have been in effect.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with respect to drainage, is rather more productive than the general run of the type that it represents.

Neither manure nor residues, used alone, has much effect toward crop improvement. A sharp increase, however, follows the application of limestone used with either manure or residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained. Rock phosphate in addition to limestone has produced no significant effect, used either with manure or with residues.

Potassium has been of considerable benefit to the corn and clover but not so much to the other crops. This suggests the possibility of a more profitable use of kainit, which furnishes the potassium, by cutting down the quantity used and applying it directly for the benefit of the corn and clover crops.

RALEIGH FIELD

As representing the soil type Yellow-Gray Silt Loam On Tight Clay, the results from a portion of the University experiment field located at Raleigh in Saline county are presented here. Series 200 and 300, which lie on this soil type,

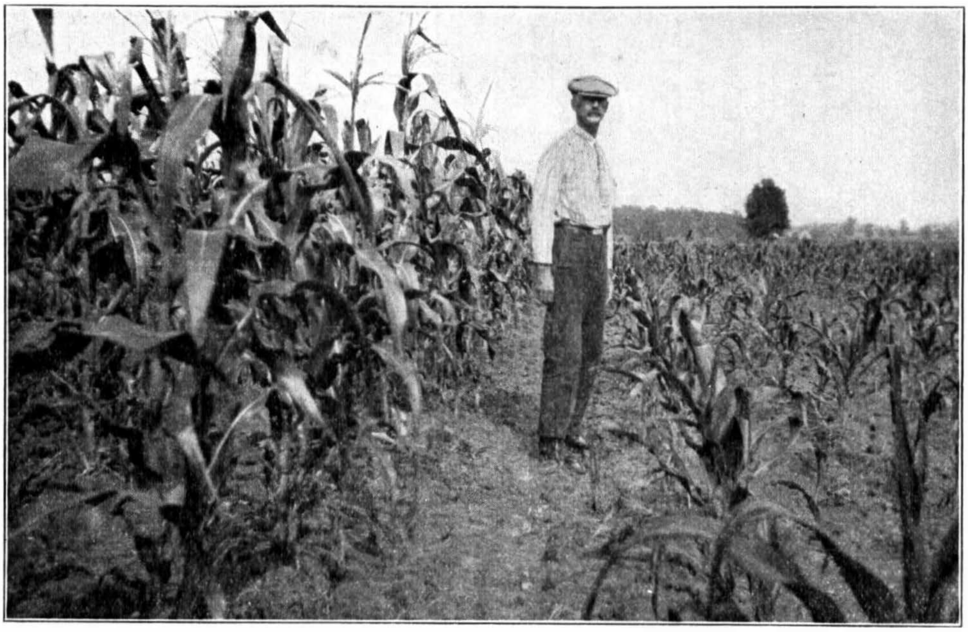

FIG. 11.—CORN ON THE RALEIGH FIELD

At the right no treatment has been applied; at the left, manure, limestone, and phosphate have been applied, the major effect being produced by the limestone and manure.

form a part of a plot system kept under a crop rotation of wheat, corn, oats, and clover. When clover fails, soybeans are substituted.

The general management and soil treatments are as described on pages 26 and 27. In 1922 the practice of returning the wheat straw in the residues system was discontinued. In the same year the regular applications of limestone were suspended until such time as lime might appear to be needed again. In 1923 the rock phosphate was evened up on all phosphate plots to a total application of 4¼ tons an acre, and the applications were discontinued for an indefinite period. The results in terms of average annual yields of the respective kinds of crops are summarized in Table 10.

A study of these data brings out the following comments concerning the effects of the various treatments on the Raleigh field:

1. The untreated plots are conspicuous in their low yields.

2. All the different kinds of grain crops show some response to the application of stable manure, altho the beneficial effect varies greatly.

3. Crop residues used alone have been of very little effect.

4. Limestone in combination either with manure or with crop residues stands out in its effect as the most prominent agency in soil improvement.

5. The application of rock phosphate has produced little effect, so that on the whole the use of this material in the manner of these experiments has been attended by a financial loss.

TABLE 10.—RALEIGH FIELD: SERIES 200 AND 300, SUMMARY OF CROP YIELDS
Average annual yields 1911-1929—bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *5 crops*	Corn *10 crops*	Oats *10 crops*	Clover *2 crops*	Soybeans *6 crops*
1	0	2.2	11.4	10.2	(.13)	4.8
2	M	4.5	23.4	15.6	(.06)	8.3
3	ML	12.8	40.0	26.3	(.64)	12.9
4	MLP	14.6	41.9	25.9	(.68)	14.2
5	0	2.6	12.1	10.6	(0)	4.6
6	R	3.9	16.4	13.6	(0)	5.1
7	RL	10.0	34.8	23.9	(.18)	10.0
8	RLP	11.5	40.0	26.4	(.32)	11.2
9	RLPK	14.5	47.3	27.3	(.60)	12.1
10	0	4.5	19.7	14.0	(.06)	8.3

6. Potassium in the form of kainit has increased the yield of all crops, particularly the corn, wheat, and clover. At current prices the value of the increase is just about offset by the cost of the kainit applied.

Regarding the cropping system employed on this field, it may be said that altho it serves for experimental purposes in determining the needs of the soil, for farming practice it doubtless could be improved either by substituting a more profitable crop for the oats or by rearranging the crop sequence and omitting the oats.

VIENNA FIELD

Effingham county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Operators of land of this kind will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 11). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

Careful records were kept for nine years. The results, summarized in Table 8 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and

TABLE 11.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average annual yields 1907-1915—bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded 4/5 of a ton on the protected series and but 1/5 of a ton on the check.

Figs. 12 and 13, page 40, serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. It appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a more profitable enterprise.

APPENDIX

PRINCIPLES OF SOIL MANAGEMENT

Clear thinking on the complex problems of soil management must start with a realization that there are many different kinds of soils, each differing from the others in soil characters. The fertilizer, management, and cropping requirements of each kind of soil are not yet fully worked out, altho knowledge regarding the agricultural significance of the various soil types recognized in the soil survey is rapidly accumulating.

Soils are dynamic, exceedingly complex, natural bodies made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, soils cannot be considered as reservoirs into which given quantities of an element or elements of plant food can be poured with the assurance that they can be expected to respond uniformly to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance to favor the growth of higher plants and of beneficial microorganisms.

It is obvious that in order to fulfill these conditions no single system of soil treatment can be laid down for all situations. The long-time records from numerous soil experiment fields scattered over Illinois demonstrate strikingly that different soils require different management practices. Some soils are naturally so productive that no fertilizer treatment yet tried has succeeded, on a paying basis, in raising the crop yields over their natural capacity. On the other hand, there are other soils so poor that altho under proper treatment the yield can be increased many fold, the plane of production under the best management known is still so low that it is questionable whether it pays to farm the land at all. Between these two extremes all grades of productivity are found. A further significant fact brought out in a study of these experiment fields is that a given piece of land seldom responds to soil treatments in the same manner thruout its history. The most efficient treatment during one rotation period does not necessarily remain the most efficient in another period.

Thus it appears that soil management is a complex matter even when considered from only one side of the problem, namely, that of producing crops. In addition to these complexities connected with production, however, are those having to do with the everchanging economic conditions by which market prices are affected. Whether a certain yield produced by a given soil treatment will be profitable depends directly upon the price of produce as well as upon the cost of the treatment, and every farmer knows only too well something of the violent fluctuations in market prices that have taken place in recent years. Furthermore, costs of fertilizing materials change from time to time, and these changes do not necessarily run parallel with the fluctuations in value of farm products.

With these facts in mind it is not difficult to understand that, from the standpoint of financial profits, a soil-management practice perfectly recommendable this year may become wholly unprofitable in another year and, vice versa, a practice that is unprofitable under present conditions may become highly profitable at another time.

The above remarks suggest something of the difficulty of prescribing definite recommendations for specific soil treatments and of the futility of making blanket recommendations to cover the requirements of all soils and all crops at all times. In mentioning these difficulties there is no intention to discourage efforts at planning programs of soil improvement; the purpose, rather, is to set forth some of the uncertainties involved and, in particular, to warn against hasty conclusions based upon scanty experience or superficial observation.

In spite of the many complexities involved in the problem of soil improvement, there are certain broad, underlying principles that are basic and that must be taken into consideration in laying out any improvement program. Underlying the permanent and profitable productivity of the soil is the maintenance of good physical condition, favorable biological activity, a suitable soil reaction, and an adequate supply of available plant-food elements during the growing season. The chief practices which accomplish these ends are—

1. Adequate drainage
2. Protection from erosion
3. Application of limestone where necessary
4. A good cropping system, including suitable legumes for soil improvement
5. Provision for active organic matter by returning regularly animal and plant manures
6. Purchase of mineral plant-food elements to supply deficiencies

PROVIDING ADEQUATE DRAINAGE

Adequate drainage is recognized as essential for the consistent production of satisfactory crops. Crops vary, however, in their ability to endure poor drainage. Alsike clover, for example, is better adapted to wet land than is red clover. Some bottom lands produce excellent summer crops but cannot be used for winter crops because of flooding. Altho such lands may not be well drained, it is often possible to raise good crops of corn on them year after year, because, as a result of frequent overflow, they receive periodically a fresh deposit of soil material. Such a practice on poorly drained upland would not be feasible. Upland soils, with few if any exceptions, require a well-planned cropping system if they are to be utilized most efficiently, and such a system is difficult to follow unless adequate drainage is provided.

Soils differ in permeability and consequently in their response to the installation of tile. There are soils in the southern and southwestern parts of Illinois, occupying a large total area, which cannot be drained successfully with tile because they have an impervious, clay-pan subsoil. In the east-central part of the state there is a soil occupying a considerable area which does not underdrain well because of an impervious glacial drift which comes to within 30 inches or less of the surface.

The soils of Illinois may well be artificially underdrained with the exception of those noted above. The soils which cannot be underdrained must be drained by means of open ditches and furrows or by means of a combination of open ditches, furrows, and tile provided with manholes thru which the water may enter the tile. In some soils the efficiency of the tile may be greatly increased by starting to fill the tile ditches with top-soil instead of with the more impervious material taken from the bottom of the ditches.

There are some soils in Illinois that cannot be satisfactorily drained either by tile or by open ditches. There should be no attempt to utilize such soils for general farming purposes.

PROTECTING SOIL FROM EROSION

The erosion problem is a serious one in Illinois. We are accustomed to think of erosion as being harmful only on rough and strongly rolling land. This seems, however, to be far from the truth.

The land surface subject to erosion in Illinois might be considered to include three groups of soils based on steepness of slope. The first group might be characterized as being subject to destructive erosion. Land of this character is located, for the most part, adjacent to streams and comprizes a total area in the state of some 7,000 square miles. Land subject to destructive erosion, is for the most part unsuited to general farming. If used for this purpose, erosion is so difficult to control that the returns do not justify the expense involved. Some of the land of this character may be used for orcharding and some of it may be used for permanent pasture but a large proportion of it is suitable only for timber.

A second group of erodible soils may be considered to include land suitable, under proper protection, for permanent pasture and orcharding but unsuited to general farming because of the steepness of the slopes resulting in destructive erosion if tilled. Land of this general character includes some 8,000 square miles. Terracing is recommendable on land of this character as affording a relatively inexpensive and an effective means of reducing erosion. There will be times however when erosion will be severe on land of this general character even on fields where the best known methods of control are being used.

Generally speaking the two groups mentioned above comprize land of relatively low agricultural value, as this term is commonly understood. If, however, certain of these soils are used for purposes for which they are adapted, they may be of considerable or, in some cases, of high value.

A third group comprizes the gently rolling to rolling land thruout the northern two-thirds of the state. Some 25,000 square miles may be included in this group. This land has a high value for general farming but is subject to harmful erosion and much of it is being seriously damaged thru the removal of surface soil by running water. The erosion problem presented by this third group is probably of more serious concern than that presented by either of the other two because of the high value of the land involved. Erosion can be controlled on a large proportion of this land by means of a good cropping system. Provision should be made for a protecting cover of vegetation particularly in the fall and spring. Cornstalks rolled down at a right angle to the slope are very effective in

FIG. 12.—PROPER SOIL TREATMENT AND CROPPING WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 13.

reducing erosion on this gently sloping land. Long shallow draws may often be kept in permanent sod to great advantage. Broad base terraces may be effectively used where the slope is a little too steep for effective control to be secured with a good cropping system only. It is surprising however how effective a good cropping system is in decreasing washing. Experimental results indicate that on relatively gentle slopes of about 4 percent the surface seven inches of soil may be washed off in about twenty-five years where a poor cropping system is used, and that the use of a good cropping system alone will extend the time for the removal of the same amount of soil to some 350 years.

The method or combination of methods suitable for the control of erosion on any given area depends on many factors; that is to say, no generally applicable,

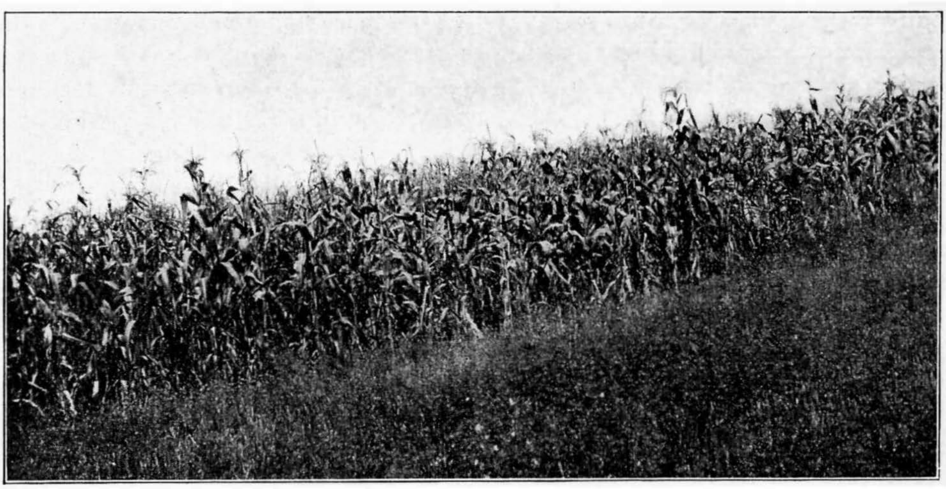

FIG. 13.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 12.

detailed directions for controlling erosion can be given because such important factors as steepness of slope, length of slope, and permeability of the soil must be taken into consideration.

A detailed discussion of methods of controlling erosion will be found in Bulletin 207, "Washing of Soils and Methods of Prevention," and Circular 290, "Saving Soil by Use of Mangum Terraces," published by this Station.

APPLYING LIMESTONE TO CORRECT ACIDITY

The maintenance of a favorable soil reaction has been mentioned as one of the essentials in a rational system of soil management, and in contemplating a soil-improvement program one of the first steps for consideration is the application of limestone.

In considering the use of limestone it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, a plant-food element for which certain crops have a high requirement. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial bacteria. It plays an essential role in the chemical transformation of nitrogen. It helps to check the growth of certain fungous diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Most important of all its properties is its power to neutralize soil acidity, thus making possible thru the growing of legumes the reclamation of millions of unproductive acres as well as the improvement of land of moderate or even high productive capacity.

Soils vary tremendously with respect to acidity, and the question arises as to how the farmer is to know whether his land needs limestone. Much information on this subject, as it pertains to Illinois land, is to be found in connection with the soil survey. Some soil types are uniformly acid, and therefore in their description attention is called to the necessity of applying limestone; other types being alkaline thruout, do not need lime, and in the discussion this fact is recorded. There are, however, extensive soil types in which the lime requirement is not uniform. It may vary from field to field on the same farm. It may even change on a given field with the passing of time, especially under heavy cropping. Obviously in such cases a definite recommendation in regard to liming cannot be given, and under these circumstances the farmer is advised to resort to a test which he himself can learn to make.

Any citizen of the state may obtain from the county farm adviser or from the Experiment Station instructions for making a systematic limestone map of his fields, showing not only the areas that need liming but also approximately the amount of limestone to apply. Such a test made on soils where the lime requirement is decidedly variable is saving many hundreds of dollars in expenditures for limestone where limestone is not needed, as well as preventing the waste of clover seed on soils too acid to grow clover. For a description of this test see Circular 346 of this Station, "Test Your Soil for Acidity."

A good indication as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover. This crop does not thrive on acid soils and its thrifty growth therefore indicates that the soil is not acid, at least in a harmful degree. Some legumes, for example red clover, will grow fairly well on soil of moderate acidity provided conditions are otherwise favorable. Too much reliance therefore should not be placed on the behavior of

FIG. 14.—SWEET CLOVER AS AN INDICATOR OF THE NEED FOR LIMESTONE

Left, no limestone; right, limestone. Sweet clover is one of the most sensitive crops to soil acidity. This crop will not grow on acid soils until limestone has been applied.

legumes as an indicator of the need of liming, for it frequently happens that fair stands are mistaken for good stands and even good yields can often be greatly increased by the use of limestone. Therefore it is well to be definitely informed regarding the condition of the soil with respect to acidity, using, where necessary, a reliable test such as that mentioned above.

MAINTAINING A WELL-PLANNED CROP ROTATION

In any program of permanent soil improvement one should adopt at the outset a good system of crop rotation, including a liberal use of legumes. It is impossible to prescribe the best rotation for every individual case because what will prove to be the most advantageous system to follow depends upon a number of different factors. Of primary importance among these factors is the location of the farm with respect to soil, to climate, and to market. The particular rotation to be followed will be determined further by the type of farming—whether grain, livestock, orcharding, or other kind of enterprise. Finally, not the least important to be considered are the personal interests and inclinations of the farmer himself.

Following are a few suggested rotations, applicable mainly to the corn belt, which are intended to serve merely as patterns or outlines, to be modified according to special circumstances. In these suggested rotation programs the more common crops are mentioned merely as types, for which other crops of similar nature may be substituted as desired. In the following lists, for example, oats may be replaced by barley or spring wheat, and likewise winter rye might take the place of winter wheat. Or it may be advisable in some cases to divide the acreage of small grain and raise different kinds; for example, plant a part of the land to oats and a part to barley. The word "clover" in the following lists of rotations is used in a general sense to designate red, alsike, or sweet clover, or even a clover-grass mixture to serve either as pasture or meadow. In the event

of clover failure soybeans may be substituted. The value of sweet clover, especially as a green manure, for building up depleted soils is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized. In the following lists the word "clover" in parentheses signifies that clover is seeded in the grain crop.

Numberless different cropping systems might be enumerated, ranging thru various long-term and short-term rotations, but it will suffice for the present purpose to mention only a few systems as suggestive of types of rotations.

Six-Year Rotations

Among the longer type of rotations the following six-year systems are suggested as being good practical rotations adaptable under many circumstances. Two such programs are presented, one in which corn predominates and the other in which wheat is the major crop. Following are the crop sequences:

System A	*System B*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)
Clover	Clover

In grain farming most of the crop residues are returned to the soil and the clover may be left on the land or returned after threshing out the seed. In livestock farming the clover may be mixed with alfalfa or with timothy, the crop being used for pasture or for meadow as desired. Soybeans, a crop that is rapidly coming into favor, can be introduced into System A by replacing either the first or the second corn crop or the last clover crop. In System B perhaps the best place for soybeans would be following the second wheat crop, altho it is possible to grow them in place of the oats.

An objection sometimes arises to wheat following clover on account of the wheat lodging. This lodging is not so likely to happen when the clover is cut as hay and removed from the land.

Five-Year Rotations

A five-year rotation system offers one of the most convenient cropping plans that can be devised for general farming. It is flexible, it provides diversification, and it can be made to give large place to legumes. Here again two different basal systems are presented, one designed primarily for corn as the major crop and the other for wheat:

System C	*System D*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)

It is of interest to observe that if soybeans were to replace second-year corn in System C or oats in System D, and the clover catch crop were allowed to grow a while in the spring before corn planting, then a legume crop would appear on every acre every year.

Four-Year Rotations

The four-year rotation represents a rather common cropping system. Among the several possibilities the following are suggested as practical programs for a four-year rotation:

System E	*System F*
Corn	Corn
Corn	Oats (clover)
Oats (clover)	Wheat (clover)
Clover	Clover

System E which calls for half the land to be in corn, requires a productive soil. However, half the land is under legumes and this is also true of System F. Soybeans might take the place of one of the corn crops in System E. In System F they might take the place of the oats provided the bean crop is removed early in order to make way for the fall seeding of the wheat.

Three-Year Rotations

One of the most common rotations practiced in the corn belt is the three-year crop succession of corn, oats, and clover (System G). From the standpoint of soil maintenance this is a good rotation. Legumes appear on the land two years out of three. It is also advantageous from the standpoint of labor economy, for plowing is required only once in three years. Its main disadvantage perhaps lies in the restricted crop diversification.

System G	*System H*
Corn	Wheat (clover)
Oats (clover)	Corn
Clover	Soybeans

An opportunity to introduce wheat into a three-year cropping plan is offered in System H. It is of interest to note that by seeding a catch crop of sweet clover in the wheat, to be plowed under the following spring just before corn planting, the land is under legumes some portion of the season every year. It will be necessary to harvest the soybeans early either by using an early variety or by cutting for hay in order to prepare the land for winter wheat. In some regions it may be desirable to substitute cowpeas for the soybeans.

Two-Year Rotation

The well-known practice of alternating corn and oats has long been pointed out as an example of a bad rotation under which thousands of corn-belt farms are headed toward ruination. However, with the advent of sweet clover, that great soil restorer, a corn-oats rotation becomes a practical possibility.

System I

Corn
Oats (sweet clover)

In this system sweet clover is sown in the oats, pastured in the fall and the following spring if desired, and then plowed down in preparation for corn. From the standpoint of soil upkeep, this cropping plan, which may fit well in certain situations, is offered as an interesting possibility, altho from the general

farm-management point of view it may lack some of the advantages of the longer rotations described above.

Altho oats are mentioned as the spring grain crop, as a matter of fact by dividing the land devoted to small grain and introducing barley, these two crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

Alfalfa and Pasture in Rotation

Alfalfa is a highly desirable crop to grow, especially in livestock farming. Its possible use as a biennial legume in the rotation has already been pointed out. It is often desirable, however, to include alfalfa as a perennial stand in the cropping system. This can be done by providing one extra field. The alfalfa occupies a field during a complete rotation period of the other crops plus one year extra. The alfalfa is then shifted to another field while the other crops rotate, and so on around the entire field system.

It may be observed that this same plan for alfalfa in rotation will provide for continuous pasture of any kind, either of perennial grass or of grass and clover mixture.

SUPPLYING RIGHT KINDS AND AMOUNTS OF ORGANIC MATTER

Organic matter acts beneficially chiefly in two ways: it helps to maintain favorable physical conditions in the soil; and it supplies food material for the microscopic organisms which inhabit the soil and which in turn, thru their life processes, effect many of the necessary chemical transformations that render plant food available for the growing crops.

The main sources of supply for organic matter are stable manure, crop residues, and green manures.

A recent study of the results from the soil experiment fields located in many different parts of Illinois reveals the fact that the system of treatment that has most frequently returned the greatest profit is manure with limestone. Of the eight systems compared, this proved to be the winning treatment on more than 60 percent of the fields. This indicates the very great value of stable manure and suggests the importance of its careful conservation and use on every farm where this material is available. On most farms, however, there is not sufficient animal manure produced to cover the land, and thus it becomes necessary to resort to some other supply of organic matter. The alternative here lies in the so-called ''crop-residues'' system, in which unused materials such as stalks, straw, and chaff are returned to the land and plowed under along with leguminous green-manure crops.

In connection with the application of organic matter, an important distinction between kinds of organic matter with respect to chemical make-up has come to be recognized within the last few years. It is commonly observed that an excessive application of straw or similar material is likely to produce a depression in crop growth which may result in lowering the yield. In addition to the unfavorable physical effect of plowing down a mass of decay-resistant material, particularly if dry weather ensues, a detrimental chemical effect may also follow.

The large quantity of cellulose contained in straw stimulates the activities of a certain set of microscopic organisms. These may become so active as actually to compete with the growing plants for nitrate and so under certain circumstances to cause nitrogen hunger. Good judgment must therefore be exercised in applying strawy material. Heavy applications should ordinarily be avoided unless they can be plowed under with a good growth of legumes or else applied at such a time as not to interfere with a crop having a large nitrate requirement.

MINERAL PLANT-FOOD REQUIREMENTS AND SUPPLY

Ten chemical elements have long been accepted as being essential for the growth of the higher plants. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium, and iron. To this list certain other elements have been added from time to time as being either necessary in the physiological processes or else present merely on account of absorption from the soil solution.

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured indirectly from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient.

Table 12 shows the average content of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 12.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw......	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	....	....	4.00	....	....	....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	....	.75	.25	.13	....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	....
Soybean hay......	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil. In presenting these figures it is not intended to imply that plants are restricted in their feeding to the surface stratum, nor that the total quantities of the various plant-food elements give a reliable indication of the immediate fertilizer requirements of a soil except in extreme cases. Such extreme cases, however, are relatively rare and there are the great middle classes in which chemical composition varies so little as to furnish no clue whatever to the probable effect of a particular fertilizer treatment. Much depends upon the ability of the crops grown to utilize plant-food material, and much depends upon the solubility of the plant-food substances themselves. When an element becomes so reduced, either in total quantity or in available form, as to become a limiting factor of production, then we must look for some outside source of supply. Table 13 shows the approximate quantities of some of the more important plant-food elements contained in materials most commonly used as fertilizers.

TABLE 13.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Superphosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 12. [2]Young second-year growth ready to plow under as green manure. [3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

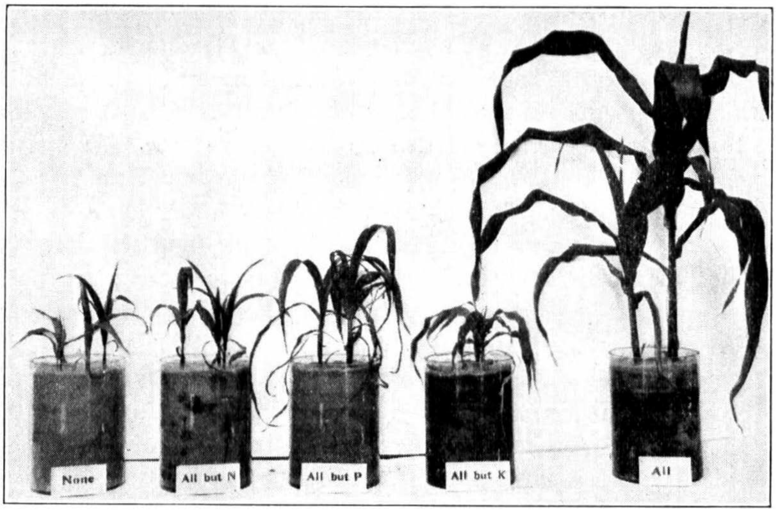

FIG. 15—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT
The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost, when purchased on the open market, is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as the clovers are able, with the aid of certain bacteria, to draw upon this supply of air nitrogen, utilizing it in their food requirements. In so doing, these leguminous plants if returned to the land add to the soil a part of the nitrogen which has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow. By taking advantage of this fact and introducing periodically into the rotation system a crop of legumes, the farmer may draw upon this cheapest source of nitrogen for soil improvement. In general farming, therefore, that is, in the production of such crops as corn, oats, wheat, and hay, legumes should furnish the main stock of nitrogen, this stock to be supplemented, of course, by all available manure and by other farm waste materials containing nitrogen.

In addition to these home sources of nitrogen supply, there are various commercial products containing nitrogen offered on the market. These materials

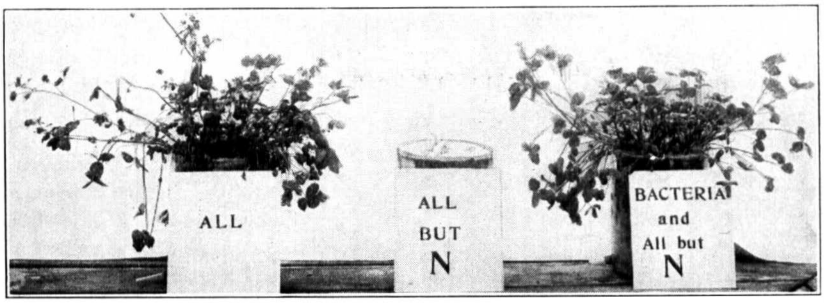

FIG. 16.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

formerly consisted largely of sodium nitrate, a mineral imported from South America; ammonium sulfate, produced in the manufacture of coal gas and coke; and certain waste and by-product materials mainly of organic composition. Within very recent time, however, tremendous developments in the synthetic production of nitrogen compounds from air nitrogen have taken place. Among these new fertilizer materials may be mentioned cyanamid, calcium nitrate, sodium nitrate, ammonium nitrate, and urea.

These developments in the artificial fixation of nitrogen will doubtless have a far-reaching effect in reducing the cost of commercial nitrogenous fertilizers. What the limits may be in this direction one dare not predict. Whether these manufactured nitrogen compounds will become so cheap some day as actually to compete with legume nitrogen is problematical, especially when the other advantages offered by legumes are considered. However, the day has not yet arrived when we can afford to dispense with legumes as a green manuring crop in the production of grain and hay.

Accepting, then, this principle that legumes and farm wastes must constitute the main source of nitrogen supply, the question arises—can these home-grown materials be supplemented to advantage by the use of commercial carriers of nitrogen?

The impossibility of making blanket recommendations has already been pointed out. The question finally resolves itself into a matter of expense and profit for each individual case. Sodium nitrate is purchased on the market at present at about $65 a ton. If a farmer applies 100 pounds an acre, he provides about two-fifths of an ounce to a hill of corn. A ton would cover 20 acres and the cost would be about $3.25 an acre. Under present prices an increase of about four to five bushels of corn or wheat would be required in order to cover the cost before any profit could be realized.

Under what circumstances might such increases in yield be reasonably expected? It is possible that in many cases where manure or legumes have not been used, such an application of nitrogen would return a profit, but such usage should be regarded as a temporary expedient rather than a permanent practice

in soil management. Under adverse weather conditions, when soil nitrates are formed too slowly or are washed away by excessive rain, an application of nitrogen fertilizer may prove highly beneficial to wheat and corn.

A peculiar hazard accompanies the application of nitrogen that does not obtain in applying phosphate or potash. Nitrates are readily washed away, and if circumstances are such that the first crop fails to utilize the nitrogen, little or no residual effect on the following crops can be expected. For this reason special caution should be used against applying excessive amounts of nitrogen. Usually it is well to divide the application of a quickly soluble nitrogen fertilizer such as sodium nitrate, using a portion at planting time and distributing the remainder at a later date. Nitrogenous fertilizers are often made up of a mixture of materials whose nitrogen becomes soluble with varying degrees of rapidity, thus automatically distributing the action of the nitrogen over a period of time.

Phosphorus Problem

Different soil types display great variation in phosphorus content and, on the other hand, soils of like total-phosphorus content exhibit great variation in response to phosphate fertilization. The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of farm manure and phosphatic fertilizers and perhaps the use of rotations in which deep-rooting leguminous crops are frequently grown. Results obtained from the soil experiment fields of Illinois show that some soils respond highly to phosphate fertilization, while others give a very low response or none. Reports from county farm advisers and farmers in general are in agreement with these experimental results.

As stated above, the total quantity of phosphorus present in a soil is not a reliable indicator of the probable response to phosphate fertilization. Apparently it is a matter of solubility or the chemical form in which the phosphorus exists rather than total quantity.

A simple field test has recently been devised at the Illinois Experiment Station which will distinguish soils having a high amount of available phosphorus from those having a low amount. Information concerning this test is furnished in Bulletin 337, "A Field Test for Available Phosphorus in Soils."

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate and superphosphate. Other valuable carriers of phosphorus are bone meal and basic slag.

Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer. Considerable experimentation in the finer grinding is under way in the hope of increasing the plant-food value of the product and thus make possible a reduction in the amount that it is necessary to apply.

Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further

processing, different concentrations are produced. The most common grades of superphosphate now on the market contain 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Likewise the 12 to 15 percent of phosphorus in rock phosphate corresponds to 29.5 to 34.3 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food, altho this fact has little agricultural significance for Illinois, where the soils generally are sufficiently stocked with sulfur. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than is the phosphorus in raw rock phosphate, altho there is often good response in the crops immediately following the application of rock phosphate.

Obviously the carrier of phosphorus that will give the most profitable returns, considered from all standpoints, is the one to use. The question of which is the most profitable, however, remains unsettled, altho it has been the subject of much discussion and investigation. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

On several of the Illinois soil experiment fields rock phosphate and superphosphate are being compared in systems of management looking toward permanent soil improvement, and are applied in amounts corresponding approximately to equivalent money expenditures. So far as these comparisons show, there appears to be little consistency in the results. In some years and on some crops superphosphate has furnished the greater profit; in other years and on other crops the reverse is true. In some cases neither material has paid for its cost, indicating that phosphorus is not a limiting factor in production on all soils. On the whole, therefore, if possible residual effects are disregarded, there appears to be no indisputable evidence for general discrimination between the two forms of phosphate.

Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium altho it exists mainly in a very slowly soluble form and probably only a very small percentage of the total potassium exists in a form available to plants at any one time.

Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils usually respond to potash fertilization. The Illinois Experiment Station has demonstrated in field experiments located on peat land that the difference between success and failure in raising crops on such land depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called ''alkali'' spots occurring on certin soil types that are rather high in organic matter, including peat and dark-colored sandy, silt, and clay loams. The unproductiveness of these soils is probably due largely to the unavailable condition of the soil potassium as well as to an unbalanced condition of the plant nutrients resulting from an excess of nitrate nitrogen. The addition of potash has a beneficial influence upon both of these unfavorable conditions.

Potash fertilizer may be procured in the form of one of the potassium salts, such as the chlorid, sulfate, or carbonate, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content.

Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned above, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

Use of Mixed Commercial Fertilizers

A mixed commercial fertilizer is a combination of substances containing either two or three of the plant-food elements nitrogen, phosphorus, and potassium. If the material contains all three of these elements, it is said to be a ''complete'' mixed fertilizer; if only two of the three are present, it is said to be an ''incomplete'' mixed fertilizer.

A complete mixed fertilizer has the general formula $N-P_2O_5-K_2O$ (nitrogen, phosphorus pentoxid, potassium oxid), the proportions of the elements varying according to the way in which the material is compounded. By substituting figures for the letters in this formula the percentage composition of the fertilizer is indicated. Thus a fertilizer of the formula 5-15-5 contains 5 percent nitrogen, 15 percent phosphorus pentoxid (usually designated as phosphoric acid), and 5 per cent potassium oxid (usually called potash). Translated into pounds, this means that a ton of the fertilizer contains 100 pounds of nitrogen, 300 pounds of phosphoric acid, and 100 pounds of potash. For the benefit of those who are accustomed to think in terms of the simple plant-food elements rather than these combinations, it may be explained that the above amounts correspond to 100 pounds of the element nitrogen (N), 131 pounds of the element phosphorus

(P), and 83 pounds of the element potassium (K). Changing the formula to read 0-15-5 indicates that no nitrogen is contained in it; 5-15-0 means that no potassium is present; and 5-0-5 indicates that phosphorus is absent.

In compounding these fertilizers, several ingredients carrying a single kind of plant-food element may be used. For example, a portion of the total nitrogen may be furnished by sodium nitrate, while another portion may be carried in dried blood or in ammonium sulfate. In addition to these plant-food materials, fillers and conditioners are often used in such amounts as to make the finished product contain the desired percentage of plant food.

A distinction between what are considered "high-grade" and "low-grade" fertilizers is now being made upon the arbitrary basis of a total of 16 so-called "units of plant food." Thus a 2-8-2 fertilizer carrying 12 units of plant-food would classify as a low-analysis grade. The advantage of using the higher grade products is becoming more and more generally recognized by both consumers and producers of fertilizers. In the latest developments still more concentrated forms of fertilizers are being produced containing as much as 60 units of plant food. If the economy of production and the agricultural value justify the general use of materials of such high concentration, there should be a great saving in the cost of transportation and handling thru the use of fertilizers of this type.

The question arises repeatedly regarding the employment of mixed commercial fertilizers, and particularly their employment in connection with a basic program of soil improvement built around the use of legumes and limestone where necessary.

An important principle to be borne in mind in the use of any fertilizer is represented in the so-called "law of the minimum," that is, that no benefit can result from the application of a given plant-food element unless the need for that element is a limiting factor in plant growth. If, for example, there is already in the soil enough available phosphorus to produce a 40-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only 40 bushels or less, all the phosphorus one might apply would be absolutely ineffective in increasing the yield beyond this 40-bushel limit.

The most serious objection to the indiscriminate use of mixed commercial fertilizers lies in the fact that frequently only one, or perhaps two, of the plant-food elements carried by the fertilizer are actually needed, in which case a useless expense is incurred for the unnecessary element or elements.

This question of the use of commercial fertilizers is exceedingly complicated because so much depends upon numberless conditions of soil and season. We may be able to analyze in part the conditions of the soil, but we are powerless in predicting the conditions of the oncoming season. A given fertilizer may pay a handsome profit this season but on the same field next year may be absolutely without effect, or even detrimental to the crop. That is why it is impossible to make any general statement or to give a blanket recommendation concerning the use of such fertilizers.

The matter finally resolves itself into two questions: cost of material and benefit derived. Fortunately the cost of material can be definitely determined.

In order to get an idea of the expense of applying mixed commercial fertilizers, perhaps we cannot do better than to figure the cost per acre based upon the published recommendations and price quotations of a fertilizer company. The following estimates are based upon the recommendations of such a company as given for the dark-colored silt or clay loam soils of Illinois on land having had manure and clover, and the prices are those quoted for the spring of 1929.

Thus, for the corn crop, 150 pounds per acre of a 5-15-5 fertilizer is recommended to be applied in drills or hill-dropped. The price of this fertilizer is quoted at $53.15 a ton, which would make the cost $3.99 per acre. According to an official report, the farm value of corn for December, 1928, in Illinois was 70 cents a bushel. At this rate an increase of 5.7 bushels of corn per acre would be required to cover the cost of the fertilizer, taking no account of the extra expense in applying it.

For spring grains the recommendation is to use a 0-21-9 fertilizer at the rate of 250 pounds an acre if drilled or 400 pounds if broadcast. The price is $45.10 a ton; thus making the cost per acre $5.64 drilled or $9.02 broadcast. If the spring grain were oats, valued at 38 cents a bushel, the increase in yield to cover the cost of fertilizer would have to be nearly 15 bushels an acre in the case the fertilizer were drilled; if it were broadcast nearly 24 bushels would be required to pay the cost before any profit would be realized. If instead of oats the spring grain were wheat valued at $1.02 a bushel, the increase in yield necessary to pay for the fertilizer would be 5½ bushels if the fertilizer were drilled and nearly 9 bushels if broadcast. In like manner the recommended application for potatoes is found to cost $13.13 an acre if the fertilizer is drilled and $26.25 if broadcast. The application recommended for pastures and meadows would cost $13.13 an acre.

The above examples afford some idea of the cost of using mixed commercial fertilizers for the production of our common field crops in so far as the prices quoted remain representative. Unfortunately it is impossible to furnish information with the same certainty concerning the profit that is likely to be derived from these fertilizers, for that will depend upon several varying factors, mainly the amount of increase in yield and the price received for it.

What kind of fertilizers will be profitable and under what particular conditions they will pay must be determined mainly on the basis of actual experience. In this connection it should be borne in mind that in all experimental trials great care must be exercised in drawing conclusions. The soil of a farm or even of a field is seldom perfectly uniform throuout, and differences in yield really due to differences in soil may easily be mistaken for effects of the fertilizer treatment. Therefore small differences in yield should be critically considered before being accepted as significant. It is particularly risky to base conclusions upon the results of a single year, because of peculiar seasonal effects. Never are two seasons exactly alike, and the results of this year may not apply next year. If outstanding effects from fertilizers occur the first year they are tried, such results may be taken as indicative and accepted as a tentative guide for further work,

but final conclusions should be withheld until these results are well confirmed in subsequent trials.

To what extent mixed commercial fertilizers can be profitably employed in connection with a basic program of soil improvement is a problem of great consequence. No doubt there are many instances in which such fertilizers may be used with profit, but it is just as certain that in many other instances their use would result in financial loss. Before investing in mixed fertilizers, farmers should carefully consider the cost, which, as explained above, is an item that can be definitely determined. With the investigations now under way, the Experiment Station hopes soon to be in possession of much more definite information than now exists regarding the use, under present-day conditions, of these mixed commercial fertilizers.

List of Soil Reports Published

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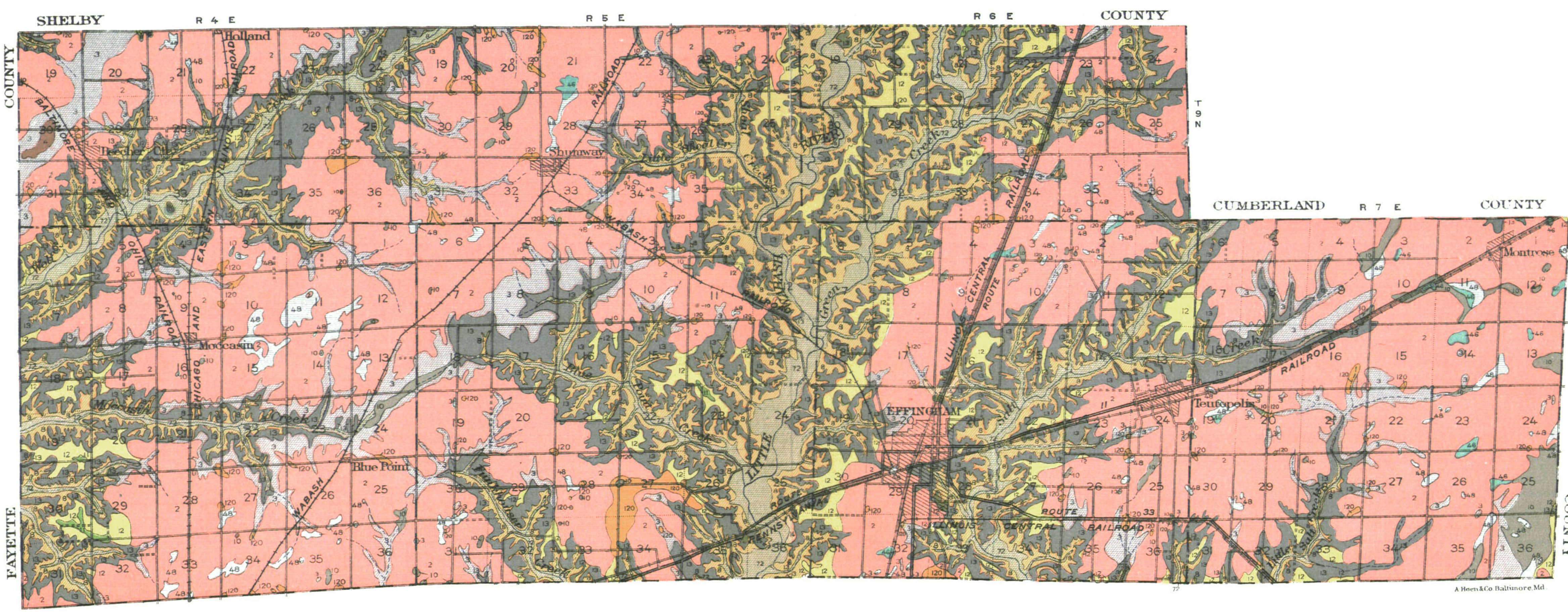


LEGEND

- 2 Gray Silt Loam On Tight Clay
- 3 Gray Silt Loam On Orange-Mottled Tight Clay
- 4 Yellowish Gray Silt Loam On Orange Mottled Tight Clay
- 10 Deep Gray Silt Loam
- 46 Grayish Brown Silt Loam On Clay
- 48 Grayish Drab Silt Loam On Clay
- 11 Light Gray Silt Loam On Tight Clay
- 12 Yellow-Gray Silt Loam On Tight Clay
- 13 Yellow-Gray Silt Loam On Compact Medium-Plastic Clay
- 14 Reddish Yellow-Gray Silt Loam
- 8 Eroded Gravelly Loam
- 120 Slick Spots
- 72 Mixed Loam

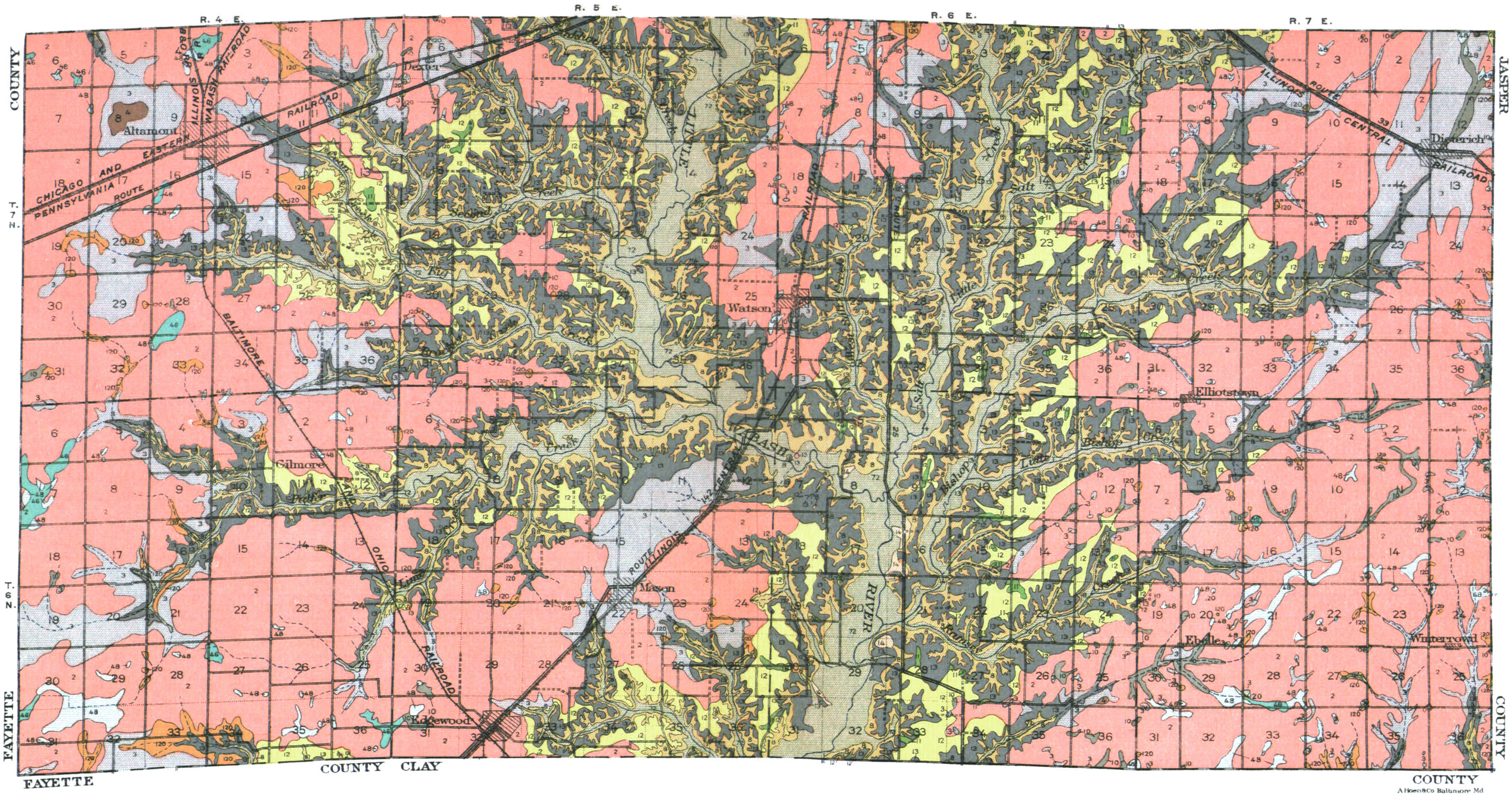
CONVENTIONAL SIGNS

- Pond
- Small areas sandstone outcrop
- Railroads
- Small areas limestone outcrop
- Public roads
- Private roads
- Township lines
- County lines
- Paved roads

SOIL SURVEY MAP OF EFFINGHAM COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

Scale
0 1/4 1/2 1 2 Miles



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